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HILTON COLLIER PRESIDENT

President's comment

Change and innovation in a land of milk and honey?

The New Zealand agricultural sector constantly needs to adapt to changing global markets and trends. So how will we confidently respond to the challenges ahead of us in the future?

In the 1960s New Zealand enjoyed a period of considerable economic prosperity. We were ranked number three in the OECD in terms of our standard of living and achieved our status on the back of a booming agricultural sector. Our farmers enjoyed favourable market access rights into the UK. New Zealand had a ready and lucrative outlet for all the red meat and butter we were able to produce. In the early 1970s the UK joined the European Common Market, but New Zealand was somewhat protected through favourable quota access. We were then faced with the first of a series of global energy shocks that saw oil prices surge to a seemingly continuous cycle of record highs.

New Zealand's response to these economic challenges seemed to be based on our efficient and low cost farming systems. Farmers were heavily incentivised through a range of subsidies. Farmers needed to focus on that all important production that brought in much needed foreign earnings. To support our farmers to achieve better productivity, the government provided technical support through the Department of Agriculture. My first job as a young graduate fresh out of Lincoln was as a farm advisory officer.

Fast forward to 2015 and we have a very different New Zealand from the one of my childhood. While we as a country can be satisfied with our world rankings on many fronts, we have not returned to the highest echelons in standards of living. This is despite our agricultural sector having enjoyed a period of strong growth on the back of our dairy sector.

A wave of milk has been lapped up by seemingly insatiable global demand. Our farmers responded to market signal – a milk price that seemed to get better and better. We have seen a significant shift towards dairy and dairy support. Traditional sheep strongholds such as Southland have become dairying regions. Our dairying systems have become more intensive with stock rates increasing, more nutrients being used and a growing use of supplements. More herds are being at least partially housed.

New Zealand seems to recognise the world is hungry for our primary production – mainly food. However, we operate in a highly competitive and ever-changing global market place. We are supposedly able to produce enough food for around 30 million people. The world population numbers around seven billion and continues to grow. If we want to sell to higher earning families able to pay premium prices for our products then we have a potential consumer base of around one billion people. This number clearly exceeds our entire food supply – we should therefore visualise and position ourselves as the world's delicatessen.

The opportunity for us is to understand consumers, interpret their 'needs' and exceed their expectations. This is different to simply producing more. Production is of course important. However, this shouldn't mean produce at all costs. Equally important is the legacy we leave to our children. Can we get wealthier from producing less, using fewer inputs, but creating higher value? Imagine a world that wanted high-value food products that offered health-improving qualities. What would people pay to be able to eat foods that treated different health disorders?

Creating value is difficult, but should be rewarding. We have a few companies who have done this. Merino NZ is an example of a company that reconfigured the fine wool supply chain. Working with companies such as Icebreaker not only helped save the fine wool sector, but also shifted this industry away from an over-reliance on woollen suits to a new category of woollen products – active sportswear. Imagine what might have been if our cross-bred wool or red meat sectors had pursued their strategy. Is our dairy sector guilty of falling into the trap of thinking a hungry world will simply consume all the milk powder we produce?

Our history shows we can change and respond. New technologies such as the internet should better connect us to world markets to understand what we need to do. The other feature that the past 30 years has highlighted is that volatility is normal. In the 1970s we had an energy shock followed by Rogernomics, the avian flu, and latterly the global financial crisis. In New Zealand we have experienced a period of strong dairy prices followed by the collapse in this current season. Our farming systems need to focus on products that are largely insulated from such volatility.

STEVE CARDEN LANDCORP CEO

Fresh thinking will transform New Zealand farming

Unlocking and developing the potential of people, livestock, land and resources in New Zealand's largest farm

Deer velvet success story

Last week a beautiful leather satchel landed on my desk. The deer nappa material made it very light, waterproof and durable. When combined with high-quality design and manufacture, it looked and felt like an impressive fashion accessory. Produced by French fashion brand Daniel Hechter, in conjunction with Timaru-based Light Leathers, the deer nappa comes from Landcorp's Mararoa farm. This partnership with Light Leathers is very much in its infancy, but is an example of the growing interest Landcorp has in working with partners able to innovate around components of the animal historically discarded as a by-product.

Crucially, the work we do on-farm to improve the quality and consistency of the deer hides, plus the story our partners can wrap around the source of the raw materials, is translating into tangible premiums across the supply chain. Otherwise, why bother? And when the retail price is $1,000 for a satchel, the raw material is a fraction of the price. So the opportunity to increase farm returns is real.

The premiums do not come easily though. Landcorp has to add value beyond just producing the raw material. So through our FarmIQ farm management system we are measuring the performance of each animal in the programme and receiving continual quality data from Light Leathers to refine our methods for breeding, feeding and handling the deer on-farm. It is hard work, highly specialised and niche.

Three problems for primary sector

There are really exciting partnerships like this happening around the country's primary sector. Innovation is rife, especially at the margins of our sector. Yet despite this, the vast majority of New Zealand's collective headspace and investment is stuck on three issues that seem unsolvable:

- The dysfunctional red meat industry
- The inability to move beyond the volatility of commodities
- The environment versus growth trade-off.

We are stuck because there are no silver bullets, and also because these problems are complex and hard discussions on them descend into frustrating circular arguments and finger-pointing. There is no lack of will to solve them. If anything, the primary sector is reminded on an almost daily basis of the slow pace of change in relation to these three problems. The challenge we have is that we have missed about a decade and a half of opportunity to solve these issues, and now the cost of solving them with our current mental models is prohibitive.

Lamb market difficult

Take lamb. Consumption per household in mature markets has been steadily declining for two decades. Why? Because we have done an average job at evolving the category to meet the changing needs of a convenience-oriented market wanting ready-to-eat healthy meals. Why have we missed it? Because we have spent two decades

and longer fighting over procurement, investing too much in processing capacity, and undercutting each other in the export markets like our trading forefathers. What the consumer wants has been largely ignored, and now they are ignoring us.

Lamb is already an expensive source of meat protein in developed markets. There is little headroom left in consumers' budgets for a 'premium' lamb offering, despite packaging innovations from the likes of Silver Fern Farms. So creating further value in the supply chain by encouraging consumers to pay more when retailers are consciously competing on price across a growing home brand range is extremely difficult.

Lamb is already an expensive source of meat protein in developed markets. There is little headroom left in consumers' budgets for a 'premium' lamb offering, despite packaging innovations.

Dose of reality

So I think we need a dose of reality. The profitability of some of our traditional primary sector products, most obviously meat and dairy, is flat. This is especially with the rapidly rising costs of compliance. The branded opportunity across these big product categories left years ago. The costs of creating that now are disproportionate relative to the size of the now diminished (in the case of lamb) or increasingly commoditised (in the case of milk powder) segment.

As Fonterra has shown, turning up late to create brands in particular categories is hugely expensive and very risky, especially without a sustainable point of difference. What was an amazing opportunity in 2000 is not in 2015. So let us stop fighting a war we arrived too late to have any chance of winning. The intractable problems our approach creates will not quickly go away while we maintain our current mental models.

It is challenges like these that are driving new thinking at Landcorp. After a review of the business early last year, we have a new vision and strategy based on five key themes that allow us to meet the challenges faced by the industry and develop new opportunities, both locally and globally.

Making the transformation

At the heart of the strategic plan is the clear recognition that Landcorp needs to unlock and develop more of the huge potential in its people, livestock, land and resources. That means:

- Achieving high rates of productivity combined with an investment in innovations that protect the environment
- Attracting, developing and retaining a high-calibre workforce – and keeping them safe
- Using our scale and brand to target premium niche markets globally by becoming partners in value chains
- Running a lean, agile business that is able to capitalise on opportunities and respond to challenges quickly.

Accomplishing this transformation of Landcorp requires a strategy oriented around the five inter-related themes.

THEME 1 – Expand through partnership

The key to our strategy is growing the volume of products we supply to specific customer contracts. A larger supply base better utilises Landcorp's scale and intellectual property, while also allowing the business to engage more effectively with its customers in the supply chain.

Landcorp will not grow its volume through significant land acquisitions. Instead, we are focused on doing so through partnerships which take two forms.

The first involves working with landowners who value Landcorp's farming expertise and seek a professional farm manager to maximise returns from their land. One example of this form of partnership is our 40-year lease of the Wairakei estate near Taupo to develop a large-scale dairy operation. A second example is the joint venture formed with Shanghai Pengxin to manage the former Crafar farms. This includes managing the expenditure of $18 million of capital improvements on those properties.

A particularly exciting partnership development is our work with iwi and other Maori organisations. As increasingly large rural land owners, iwi are welcoming opportunities to work with Landcorp to develop the productive capacity of their assets. Last year we formed a strong partnership with the Hauraki Collective, a collection of five iwi, for profitable and sustainable farming of the Pouarua dairy complex.

Pouarua is more than a well-performing dairy farm that currently has 5,300 cows, eight dairy units with a permanent staff of 33 people. It is a showcase for cooperation between Landcorp and local Māori who are restored as landowners by a Treaty of Waitangi settlement. We have applied this model to a dairy partnership with iwi in Northland and to a livestock partnership in the lower North Island. Over the next five years we would like to expand into further partnerships with iwi across the country.

The second form of partnership used to expand volume of product supplied is our work with groups of farmers interested in joining our customer contracts. This year we have established partnerships with two groups of regional farmers, one in the Wairarapa and another from Banks Peninsula. These farmer groups have an interest in joining our supply contracts and gaining access to the genetics and farm systems Landcorp uses. We hope to expand our network of farm partners into the future.

THEME 2 – Creating value for our customers

Increasing volume alone will not be enough – we need to be paid more for what we produce. As farmers, we often feel disconnected from the end market. Yet it is the end market we need to understand most because that determines not just how we farm, but what we farm. Accordingly, we are working with partners across our suite of products to connect with customers who value what Landcorp can offer. Historically, they have valued the scale and consistency of our supply, but that is no longer enough. We expect them to demand more of us than that, because they are in turn targeting consumers who expect more from them.

An example is our relationship with Tesco and Silver Fern Farms, where Landcorp lamb is the exclusive source of the Tesco Finest lamb range. Delivery of 6,000 lambs per week for six months of the year presents some significant logistical challenges across our 80 livestock farms across the country. These challenges grow when the customer expects particular genetics, narrow weight ranges, and very strict on-farm quality practices. We cannot pull that off without advanced on-farm management systems. A key innovation has been the implementation of the FarmIQ farm management system, which has taken the precision of our farming decision-making to an animal-by-animal level.

Our recent partnership with New Zealand Merino to manage our entire wool clip reflects our desire to develop deep relationships with a limited number of supply chain partners who are very market-oriented and innovative. New Zealand Merino is the country's leading merino wool marketer and, combined with our expertise in producing high quality coarse wool, we are seeking to elevate the return potential of what has become almost a by-product for many sheep farmers.

Landcorp is also looking at new product categories, and as noted earlier deer leather is one.

Another is sheep milk, which is more widely consumed globally than cow's milk, although very little is traded worldwide. It contains some extraordinary nutritional characteristics and could be less environmentally taxing to produce. As such, we believe it has enormous appeal as a niche premium product.

After a year understanding consumer preferences and product opportunities through Massey's Riddett Institute, our confidence in the demand for sheep milk-based products is growing. We have concurrently been exploring the supply part of the equation. The genetics and farm systems will present their own unique challenges, but we have cautious optimism that we can tackle these.

THEME 3 – Farming smarter

Key to Landcorp being a leader in more profitable and sustainable farming is our commitment to improving the efficiency across all our operations. As a large-scale

farmer, Landcorp must continually improve the efficiency of its operations. Last year we reached a major milestone with the successful roll-out of Farm IQ's farm management system across our network of farms.

This software, the most sophisticated of its kind in New Zealand, means we can monitor the performance of our entire network of 137 farms in real time and measure weight and determine feed and treatment requirements for our 1.6 million livestock stock units. It also allows each farm to accurately record soil, pasture, animal and environmental performance. This information is used by each farm manager to lift productivity while improving the precision of inputs applied to our farms.

New Zealand remains a world leader in some farming science but we need to position ourselves better for widespread industry take-up of new technologies and practices. In this respect, Landcorp is keen to help other farmers utilise new technologies to help improve their productivity. We have created a dedicated R&D and innovation team tasked with developing partnerships with organisations at the leading edge of on-farm science and technology. Lots of innovation occurs in different pockets across Landcorp's farms already, and this team will ensure science, technology and data is applied across our 140 farms.

Landcorp has also developed a farm-wide programme to improve productivity utilising Lean and Six Sigma manufacturing techniques. Designed to reduce time wastage, simplify processes and eliminate costs, Landcorp believes a structured approach to process improvement and planning will complement the initiatives the farm staff already have underway on each farm. We are learning off other corporate farmers who have taken the lead in this area. The programme also extends to the central office as Landcorp scrutinises how it can reduce the overhead of its corporate operations and, more importantly, improve its impact.

THEME 4 – Rejuvenating the environment

New Zealand farming has much to be proud of in its management of the environment, despite the prevailing commentary across the country. Landcorp appreciates the current sentiment of concern over the impact of farming on the environment, especially in its dairy business. We have

tried to future-proof our business in anticipation of more stringent council regulations with significant investment in new effluent storage facilities and an extensive waterway fencing programme. We have more than 6,000 hectares of forest covenanted under Department of Conservation or QEII covenants.

However, rejuvenating the environment means shifting away from a compliance mindset where success is defined by meeting minimum regulatory standards. The challenge we have set ourselves at Landcorp is to source solutions that both enhance the environment and our bottom line. The focus of our environment strategy is on the systemic rejuvenation of the environment, alongside the productive and profitable use of land. That requires searching for scientific and technological solutions, many of which are unknown to us at the moment. It also means finding leading science and farming groups who excel in particular areas, such as water management, and following their lead.

We have set ourselves the target of being carbon neutral by 2025.

We have set ourselves the target of being carbon neutral by 2025. In addition to renewable energy programmes, we will also need to plant 1,000 hectares of forestry each year across our farms on land considered uneconomic. We expect some of this forestry to be manuka varieties, developed as part of a Primary Growth Partnership we have invested in to boost farm incomes from honey.

Our second goal is a substantial reduction in the amount of nutrients lost below the root zone by 2025. We are establishing four 'future farms' in our dairy group where we will adopt innovations from across the country designed to reduce nutrient run-off. A focus on precision farming, with the implications for precise applications of inputs to optimise yields, should have a positive impact on both environmental and financial returns.

This begins by integrating environmental protection and enhancement into all aspects of farm management. By July 2015, every Landcorp farm will be operating with a Land and Environment Plan (LEP). Each plan is based on a comprehensive survey of the farm's land type, topography, waterways and other natural features, combined with a history of its productive use paddock-by-paddock. It maps out the farm today and lists the management action required to achieve sustainability in both environmental and productive terms.

As importantly, every farm will be measured against two scorecards – a financial assessment, and an equally rigorous environmental scorecard. Each farm's performance will be benchmarked on both measures, with solutions sought that concurrently improve the farm's economic and environmental outcomes. This will help build within Landcorp a new way of thinking about the environment.

THEME 5 – People are the difference

Farming should be an attractive career option for the nation's best and brightest. However, through a combination of misconceptions about the nature of the work and rural isolation the sector has long struggled to recruit enough young people. Landcorp has doubled its efforts in recent times to develop career pathways and promote farming as a rewarding career for young people. Initiatives like our Farm Manager Dairy Accelerator programme, where talented young workers are offered structured business and on-farm management training, have already proven remarkably successful at preparing the next generation of farm owners and managers.

Another important focus for us is ensuring our people are safe on the farm. New Zealand has had a poor record of safety in the primary sector, with far too many injuries and fatalities. We have worked hard to make safety a much higher priority through a range of initiatives, including our Play it Safe campaign, which has brought about fundamental change in health and safety attitudes and behaviours across Landcorp. The campaign is designed to encourage employees to talk about safety on-farm, implement practical improvements, and hold each other accountable for everyone's safety on the farm.

Our goal is to create the safest and most enriching work environment possible for talented and motivated people. We are giving top priority to health and safety in recognition not only of the importance of a safe working environment for all employees, but also because we see a clear link between our safest farms and those that are our most profitable.

Leading the way

As a statutory body, our responsibility to our shareholders – the people of New Zealand – is to run a profitable and efficient business with a strong sense of social responsibility to the communities in which we operate. Our focus is very much about securing the long-term profitability of New Zealand agriculture. Although our strategy is informed by the broader trend in food production, we are also working hard to build a company that is flexible and agile enough to respond effectively to the more immediate challenges and opportunities.

In the past year we have made strong progress and continuing that momentum is our prime focus in 2015 and beyond. We will continue to challenge ourselves, and the industry, to find better and more effective ways of doing what New Zealand does best – farm.

STEVE CARDEN is Chief Executive of Landcorp based in Wellington. He is the author of New Zealand Unleashed, published by Random House in 2007. Landcorp is a state-owned enterprise and New Zealand's largest farmer.

PETER FENNESSY

Genetics and breeding

Advances in genetic improvement have generally been built on the back of technological changes. Major technological advances in computing power, reproductive technologies and statistical analysis techniques have been huge contributors.

Now DNA technologies offer considerable opportunities, but the practical consequences (and implementation) of the use of these new technologies are very much a function of the structure of the breeding programs and the route to market.

New discoveries

The understanding of genetics of living systems is in an extraordinary phase of development. This is driven off new technologies, especially in DNA (and RNA) sequencing and the ability to get down to levels of detail where even the sequence of the DNA of single cells can be defined. The impact is especially evident in the rapid decline in the costs of DNA sequencing, which has been driven off the demands of medical science. We are reaping the benefits in agricultural species.

New discoveries are having a profound effect on our understanding of inheritance, the genetics of variation between individuals and the genetics of traits. There are new insights around the perplexing question of how the environment influences the expression of genetic variation and the plasticity of the response of the genome to the environment, especially in the early stages of development (in utero in mammals).

However, despite these extraordinary advances genetic progress in the species important to New Zealand pastoral agricultural has been based on the somewhat mundane, but highly effective, use of well-designed schemes to collect and analyse data from animals recorded on-farm. Similarly, in pasture plants the successes have been due to breeders designing mating programs. This may include the use of widely differing parents such as from different

geographical origins, then selecting the best to breed on, and then multiplying up the desirable plants.

Our interest at AbacusBio is in genetics and its practical implementation through the selection and breeding of many species. This includes livestock (sheep, dairy cattle, beef cattle, deer), plants (ryegrass, clover and some tropical species such as sugarcane), aquacultural species (salmon, paua), and insects (honeybees) and microbes. The common feature across this extraordinary range of living organisms is variation in DNA, and its re-organisation from generation to generation, and in particular how this variation can be interpreted and the knowledge then applied in practical breeding.

Selective breeding animals and plants – contrasts and similarities

Virtually all of the above are out-crossing species. Importantly, most of the species that are important to New Zealand pastoral agriculture (livestock and pasture species) are obligate out-crossers. In such species, in-breeding is a recognised problem. However, the tolerance of in-breeding is often a key difference between animals and plants. In fact, a major factor in the great progress in corn breeding has been due to the ability to produce viable in-bred lines that when crossed yield very high-performing hybrids.

Genetic improvement is based on recording the performance of individuals, i.e. the phenotype, and then selecting the desired ones to use as the parents of the next generation. The effectiveness of this approach depends on the differences being measurable and at least partly heritable, i.e. that a proportion of the variation is heritable. In analysing the data using statistical approaches, the analysis is structured to make inferences about the genetic merit of individuals. Such estimates are expressed as estimated breeding values (EBVs), the common language for the expression of genetic merit.

At the recording level there are some key differences between plants and animals in how genetic improvement is managed within breeding programs. In animals, the performance is generally measured in production herds and flocks, whereas in plant breeding this recording is carried out within structured populations run by breeding organisations and companies, which is also the case with pig and poultry breeding.

However, as noted below, there are situations now when recording difficult and expensive traits in cattle and sheep where the intensive centralised recording of genetically well-connected individuals may be the most effective approach to improvement in the so-called 'hard to measure' traits. These are the traits which are very expensive to measure, such as feed intake, or can only be measured on a carcass or meat sample.

The core components of the success of genetic improvement programs are the value proposition to the farmer and the effectiveness of the route to market. Simplicity of implementation on-farm is critical to success and this is the area where advances in technologies have had a key part to play. Examples include the development of systems for herd testing on-farm, for artificial insemination in dairy cattle, for replacing perennial ryegrasses with cultivars containing safer versions of endophytes, and for tetraploid ryegrasses that filled a particular feed-deficit niche.

Importantly, the simplicity of implementation on a commercial farm is generally via activities that need to take place anyway: examples include delivery of improved animal genetics via sires (in the case of dairy artificial insemination the cows are available twice daily), and re-grassing following cropping. Hence, the use of better genetics at the commercial level does not require a fundamental farm system change.

Success of genetic improvement in animals

The practical application of genetics continues to yield outstanding success for New Zealand primary production. In this respect, the value of the application of statistical approaches in agricultural species is well known. The ongoing genetic progress in the yield of milk solids in dairy cows, and where the annual gain in protein and fat is worth about $10 per cow per year, is a great example. In sheep in New Zealand, about half or more of the

productivity gain of the more than 10 kilograms in carcass weight sold per ewe mated over the last 25 years is due to genetic improvement (in numbers of lambs born and growth rate).

This progress has been founded on some key technologies. Progeny testing, artificial insemination and fresh low-dose semen in dairy cattle have enabled the identification of elite bulls and their widespread use through the industry via fresh semen and bull of the day schemes. Central progeny testing in sheep has enabled the evaluation of the same rams in multiple flocks.

In both cases the progeny of the same sires in multiple herds or flocks enables an estimate of the common genetic component of the variation, i.e. it provides a progeny test. In other words, the ongoing genetic progress in our livestock industries is due to how:

- We organise our breeding schemes to ensure the data are collected on-farm, and are available for and managed for statistical analyses
- The results are presented so as to be readily interpretable by users
- The better animals are used in the industry, i.e. how effectively their 'genes' are disseminated.

This all infers a level of cooperation and organisation within an industry structure!

The practical application of genetics continues to yield outstanding success for New Zealand primary production.

The methods of analysis are improving all the time. For example, the widespread use of Best Linear Unbiased Prediction (BLUP) methods in the last 30 years has made analysis much more tractable. Computing power has played a critical role. While we now take it for granted, it has been and is a vital enabler. There are three key factors in the analysis of data – an accurate pedigree, accurate data recording on-farm, and ways to minimise the complications of allowing for different environments:

- In the dairy industry, this involves recording production through herd testing and milk analysis
- In sheep, beef and deer, it involves breeders collecting their own data such as tagging ewes and lambs at birth, recording numbers of lambs born, weighing animals and recording their data
- In sheep and deer, the data are managed by bureaus and then analysed by Beef + Lamb NZ Genetics. Central progeny testing of sheep is also supported by Beef + Lamb NZ and is designed to identify sources of high-performing rams by extending and strengthening comparisons across flocks and breeding groups through creating better genetic connections across flocks.

Thus the ongoing success of practical genetic improvement owes its progress to the organisation of breeding programs, especially the principles around the definition of the genetic merit of individuals and the effective utilisation of high merit individuals in breeding schemes. The breeders' equation sums it up: *Rate of genetic progress = (selection intensity x genetic standard deviation x accuracy of selection) / generation interval.*

Selection intensity is the proportion of the population that is selected to be the parents of the next generation. Hence scale, combined with reproductive technologies, is especially important as it enables more intensive selection of superior individuals. The genetic standard deviation is a function of the heritability and the total (phenotypic) variation in the population. The accuracy is a function of the quality of the records. Thus the accuracy of the estimate of the genetic merit of a bull is much greater if the value is derived from a number of his progeny, than if it was just a record of his own performance, which is much more susceptible to environmental influences.

The effectiveness of progeny records is especially evident in the international dairy industry, where it is relatively simple to collect high quality performance data and bulls can be easily evaluated through artificial insemination and progeny testing. Those that excel, thus improving selection intensity and the accuracy of selection, can be very widely used through artificial insemination.

Impact of DNA analysis

DNA analysis has been used to detect carriers of inherited diseases, especially in dairy cattle and now increasingly in beef cattle, for the last 20 years or more. Similarly, the technology has been used to detect carriers of useful mutations such as the Inverdale gene in sheep or 'double-muscling' variants in beef cattle. However, traits of economic importance in both animals (growth rate, fertility, fecundity, carcass characteristics) and plants (seasonal dry matter yield, quality, persistence, root depth) are generally due to the collective actions of many genes so are not amenable to such simple tests.

The first inroads of DNA analysis of any scale in sheep and cattle came at the accurate pedigree step. The immediate benefit of a rapidly declining cost of DNA analysis was more accurate parentage, which could now be checked rather than relying on 'observational' records:

- In dairy cows, it meant more accurate progeny testing
- In sheep, it removed the limitation on the number of ewes a shepherd could look after at lambing as it was no longer important for them to match ewes with their lambs; it could now be done with DNA testing of the potential dams, sires and lambs. It also enabled multi-sire mating as sires could be defined.

Silver salmon – three-year-old assessment

The technology has now moved to a new level where the DNA make-up of an individual (the genome) can be described at a much deeper level relatively cheaply and quickly (through thousands of single nucleotide polymorphisms or SNPs). This progress has enabled genomic selection, which is now well established in the dairy industry. The general consensus from the recent literature is that genomic selection utilises relationship data so that it actually represents a more sophisticated and 'accurate' pedigree than recorded pedigree for two reasons – recorded pedigree is prone to human error, and the genomic relationship accounts for Mendelian sampling, which occurs at each conception.

Advances in genetic improvement have generally been built on the back of technological changes.

When combined with knowledge of the genetic merit of individual ancestors, genomic selection enables a better prediction of the genetic merit of the candidate. This is expressed as the EBV. Such technologies are applicable to both animals and plants, but the structure of genetic improvement programs is a key factor in determining how, and if, such approaches will be used. For example, genomic selection works very well in dairy cattle because of three key factors:

- The pedigree structure within the various dairy breeds, and especially the Holstein-Friesian
- The population structure – very small effective population size within breeds
- Phenotype quality – the quality of phenotypes for dairy bulls is exceptional as it is based on (sire)-daughter data, i.e. the phenotype is effectively a weighted value based on daughter records rather than on the individual itself.

Genomic selection can overcome the long generation interval required when progeny testing animals for traits only expressed in females, so that in dairy cattle there is a very strong value proposition based on existing records without expanding the selection criteria too hard to measure traits.

While the applications in sheep and beef cattle lag those in dairy cattle due to different industry structures, the impact is also expected to be profound in these industries. This will be especially the case for the hard to measure traits. Examples are feed intake or feed efficiency, methane yield, meat quality, etc. New industry structures, which provide for the measurement of relatively few individuals in central 'information nucleus' herds, are likely to be required. These herds are also likely to include very influential individuals within natural industry structures, and so long as the genetic relationships are maintained they will probably ensure high quality genomic predictions.

In pasture plants, DNA analysis is being used to understand relationships among the varying different broad classes of cultivars within a species such as perennial ryegrass. However, practical systems that seek to define parentage of individual plants, and then use selected individuals in breeding programs, have yet to be implemented on any scale. The challenges of how to utilise these new technologies in practical breeding schemes that are economically sensible are not trivial. Another relevant application of DNA analysis is the characterisation of the various strains of endophytes that are available for use in commercial cultivars of ryegrasses or fescues.

Honey bees offer a fascinating example of how DNA technologies are being implemented in a breeding program. In-breeding is a major issue in bees, and in structured breeding programs that are usually characterised by limited genetic diversity, it is critical to minimise its impact. Artificial insemination is used in these bee breeding programs so that mating can be managed. Bees do not have sex chromosomes as in animals and birds, but rather they have a gene for sex determination. A DNA test for the different variants (alleles) of this gene is therefore now being used to avoid matings that could lead to bees that are homozygous for the sex alleles. The consequence is that minimising in-breeding enhances hive viability.

Future

Advances in genetic improvement have generally been built on the back of technological changes. Major technological advances in computing power, reproductive technologies and statistical analysis techniques have been huge contributors. Now DNA technologies offer considerable opportunities, but the practical consequences (and implementation) of the use of these new technologies are very much a function of the structure of the breeding programs and the route to market.

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JOHN CARADUS

Forage plant genetics

How are we moving to raise the rate of genetic gain?

Plant breeding has been and continues to be a valuable and necessary part of improving agricultural production and productivity. This article looks at how plant breeders work, for instance, to develop new cultivars, rate their performance and improve genetic gain.

What are plant breeders trying to do?

The driving force for delivering value through the genetic manipulation of agriculturally important plants is to breed cultivars that provide a benefit to the user, namely the farmer and ultimately the consumer. Plant breeders aim to influence the phenotype of the plant through genetic selection, while acknowledging that the environment can also have a dramatic effect on the expression of plant traits.

To minimise the effect of the environment plant breeders can select populations and plants in multi-site breeding trials. Even then environment can override the best efforts of breeders. For pastoral farmers using modern (and even older) cultivars, and then either over-grazing or under-grazing them, can have a negative effect on plant performance, affecting both yield and persistence. Plant traits targeted by forage breeders include yield, persistence and quality and these are often further differentiated into:

- Seasonal yield
- Resistance or tolerance to biotic and abiotic factors affecting persistence
- Specific quality traits such as energy or protein levels
- The absence of anti-quality factors such as lignin or anti-metabolic compounds.

Current methods used by forage breeders

Plant breeders are attempting to exploit natural genetic variation found within the species of interest. Most of the forage species of interest in New Zealand are out-breeding species which means that every plant, even within discrete populations, is genetically different and distinct. The aim for the breeder is to select genotypes that express the trait of interest and then cross the selected genotypes with each other to create a new population (or cultivar i.e. cultivated variety) that expresses that trait at consistently high levels, hopefully across a range of environments.

Plants have different breeding systems, but they can be classified into the following two broad categories of out-breeding and in-breeding.

Out-breeding

This is where pollen from another plant genotype is required to fertilise the ovule and produce a seed. Plant species use several mechanisms to encourage cross-pollination. Male and female reproductive organs of a flower may mature at different times, a condition called dichogamy. There are two types of dichogamy:

- Protandry, where pollen is produced by the plant before the ovules of that plant mature, and this is found in species such as maize and carrot
- Protogyny, where female reproductive organs of a flower mature before the male organs as found in plantain.

Most of the forage species of interest in New Zealand are out-breeding species which means that every plant, even within discrete populations, is genetically different and distinct.

Alternatively, some species can have the male (stamen) and female (pistils) organs on different plants. This is called dioecy and occurs in species such as asparagus and hops. In other species there is the option for genetically determined self-incompatibility, where the pollen will not germinate and grow on the stigma of the same plant, as occurs in white clover, ryegrass and cabbage.

In-breeding

This is where pollen from a plant can fertilise the ovary of the same plant and produce a seed. Many annual species such as wheat, barley, rice, peas, beans and tomatoes are predominantly self-pollinating. In forages this also includes many annual legumes, such as subterranean clover and some grasses, such as prairie grass.

Developing new cultivars

Forage plant breeders who mainly deal with out-breeding species can use a number of options for developing new cultivars:

Mass selection

This is where selections are made of individuals based on their phenotype. All plants are crossed together and the seed harvested is bulked to grow the following generation. There is no option to evaluate progeny from individual parents.

Ryegrass isolation block with Triticale grown as the pollen barrier

Family selection

Among and with family selection can be achieved using either:

- Half-sib progeny from a set of individuals resulting in populations that are related to each other through crossing using a polycross design, where all plants have an equal opportunity to cross with all other plants, or
- Full-sib progeny from just two selected plants that are crossed with each other.

In both cases, progeny can be tested for performance and trait inheritance measured based on the maternal line.

Diallel crosses

These provide a mating scheme used to investigate the genetic control of quantitative traits. In a full diallel crossing scheme all parent plants are pair-crossed with each other and seed is harvested off both parents. Diallel crosses allow calculation of heterotic groups, and estimate general or specific combining ability, interactions with testing environments and years, or additive, dominant and epistatic genetic effects and genetic correlations. As well as gaining a better understanding of the genetic control of a particular trait of interest this crossing design leads to the identification of superior parent genotypes for cultivar development.

Recurrent selection

This can be used in a number of breeding strategies and simply refers to the selection of plants over several generations with inter-breeding of selected plants to provide better genetic recombination. Recurrent selection is an efficient breeding method for increasing the frequency of superior genes for a trait or traits in a population. For out-breeding species it ensures that high genetic variability is maintained in a population due to repeated inter-mating of heterozygous individuals.

Semi-hybrid development

This is where two in-bred or partially in-bred populations are crossed with each other to provide improved performance though hybrid vigour, a system used effectively for maize.

Combining ability

The combining ability of a genotype for expression of a trait is an important consideration because this determines the capacity of an individual to transmit superior performance to its offspring. There are two types of combining ability:

- General combining ability is an average performance of an individual in a particular series of crosses. It is influenced by the additive genetic variance and additive x additive gene interaction
- Specific combining ability measures the performance of a parent under consideration in a specific cross. It represents the deviation from general combining ability caused primarily by all the three types of gene interactions – additive, dominant and epistatic genetic effects.

Overlaying these breeding strategies is the need to be able to accurately and reliably measure the phenotype. This can be time-consuming and often requires a good eye, i.e. the ability to accurately see and quantify the desired variation, good agronomic knowledge of the plant species, and a physiological understanding of how particular traits impact on performance.

All breeding programmes start with screening a wide range of germplasm for the desired variation. In New Zealand, all of our economically important plants are introduced species and so sourcing new variations almost certainly requires the introduction of new germplasm. To provide useful genetic variation these introductions are preferably collected from close to the source of the species centre of diversity, or alternatively from regions with a climate known to be slightly more extreme than that found in New Zealand. However, germplasm collection is becoming increasing difficult as countries close their borders to such activities, and as terrorism and war zones in some regions make collection trips too dangerous.

Selection trials in most forage breeding programmes use several sites with realistic environmental impacts. So for white clover breeding the plants are grown in a competitive ryegrass sward with regular grazing imposed in an attempt to mimic the 'real world'. In this situation, plants are grown in small plots or rows and so selection is based on population rather than individual plant performance.

Protecting plant breeders' interests

The introduction of plant variety rights (PVRs) or plant breeders' rights (PBRs) has allowed plant breeders to manage their intellectual property and gain a financial return for the investment in breeding new improved cultivars. To gain PVRs a breeder must produce a cultivar that can be shown in independent trials to be unique, genetically stable and uniform.

Uniqueness is usually determined using morphological characters. Being genetically stable is measured by comparing two different generations of seed of the

cultivar, and uniformity is determined by measuring the extent of morphological variation within the cultivar. Protection of a new cultivar using PVRs must be attained within a year of first commercial sale. In New Zealand, the current Plant Variety Rights Act was legislated in 1987 and is in need of review to bring it into line with international direction and thinking in this area.

How far have we travelled to date?

Forage plant breeders have been active in New Zealand for at least 80 years. An effective way of estimating genetic gain is to grow cultivars developed over several decades in the same environment and then measure the improvement in performance and analyse by averaging cultivar performance by decade of release. This has been done for most of our forage species of importance, and gains in forage yield have at times exceeded one per cent per year, as indicated **Table 1**.

This would mean that over a decade we would expect to see a 10 per cent increase in dry matter production, and while this can be demonstrated in breeders' plots it has often been a challenge to deliver this on-farm. Overlays of environment, either natural (e.g. droughts, pests and disease) or man-made (e.g. grazing management), tend to constrain the genetic potential demonstrated by breeders.

Table 1: Estimated rate of genetic gain through breeding on traits in a range of forage species

Species	Trait	Genetic gain (% per year)
Lucerne	Forage yield	0.3
Red clover	Forage yield	0.4 –1.4
White clover	Forage yield	0.6 – 1.5
	Stolon density	1.1
	Nitrogen fixation	1.2
	Lamb growth	0.3 – 0.5
Perennial ryegrass	Forage yield	0.3 – 0.9
	Lamb growth	1.4
Annual ryegrass	Forage yield	1.2
Tall fescue	Forage yield	1.0

However, the genetic gain due to breeding of forage species is generally less than that of the major annual crops. The challenges of forage plant breeding compared to annual crops are that:

- Forage breeders are mainly dealing with perennial plant species with long breeding cycles, particularly if persistence is a trait under consideration
- Pasture species are often grown in complex mixtures
- There is no defined plant part that is harvested
- There are a multitude of plant traits to consider
- Plants are grazed and this may be frequent, infrequent, hard or lax
- There is a moderate international breeding effort
- Some grasses may contain fungal endophytes which can complicate breeding.

How do we rate cultivar performance in New Zealand?

In some countries, particularly in Europe, there is legislation requiring cultivars to be tested for agronomic performance. Only those that show a significant improvement over standard and current cultivars are then listed and allowed to be marketed. This system seems fair and a good way of protecting the end-user from purchasing seed of a poor cultivar, but it does have some pitfalls.

First, these trialling systems are expensive to run and are undertaken using a mowing/cutting regime. Second, they do not have real on-farm defoliation and management systems imposed. This has motivated plant breeders to set up breeding trials mimicking this type of trial management, so that they can develop cultivars that have a good chance of getting onto the list for marketing.

In New Zealand there is no legislated trialling system. Under the auspices of the New Zealand Plant Breeding and Research Association forage plant breeding companies have developed a National Forage Variety Testing system. This is a voluntary system where entries are tested using strict protocols that attempt to replicate on-farm management systems. Use of data from these trials by DairyNZ has led to the development of the forage value index which provides a rating list of cultivar performance across regional New Zealand.

This development has increased the enthusiasm of plant breeding companies to be involved in the National Forage Variety Testing system. Currently, only annual and perennial ryegrass cultivars are included in the forage value index. However, it is a start and does provide, at least for dairy farmers, an independent guide to the economic value of cultivars in their region.

What are the options for improving genetic gain?

Current methods regularly used by forage plant breeders to develop new cultivars were identified above. So looking forward what might be available as new options for breeding? Possibilities include:

- Marker-assisted selection and, more recently, genomic selection using genotyping-by-sequencing (GBS)
- Targeted mutagenesis, which includes genome editing techniques such as TALENS and zinc finger, amongst others
- Intragenic or cisgenic cultivars – no introduced foreign DNA
- Transgenic cultivars – genetic modification – leading to genetically modified organisms.

Marker-assisted selection is used effectively in some breeding programmes worldwide, particularly larger ones. For example, most cereal breeding programmes use genetic markers for some disease screening as part of their selection programme.

Genomic selection using GBS is a new approach to marker-assisted selection. It is viewed as a valuable method for plant breeding and it is predicted that it will be

integrated into many practical breeding programmes in the near future. New Zealand is investing in this technique for both plant and animal breeding. It is expected that this technology will allow plant breeders to conduct genomic selection on a novel germplasm or species without first having to develop any prior molecular tools.

Mutation breeding seeks to extend the range of known variation and can take on many forms from simple chemical or radiation-induced mutations, followed by phenotyping of large populations looking for random mutations of value, to specific gene-targeted mutation breeding. Intragenic or cisgenic breeding is considered genetic engineering in New Zealand and is regulated, despite the fact that no foreign DNA is introduced into the genome of interest.

Our farmers are clearly limited in international markets by not having the advantages of the production efficiencies that are offered by genetically modified crops in other countries reliant upon exporting food.

Genetic modification, which is regulated in New Zealand, is an extension of traditional plant breeding with one very important difference. It allows for the transfer of a greater variety of genetic information, usually only one or a few desirable genes, in a more precise and controlled manner. For most traits in crops the risks of genetically modified crops to natural ecosystems, agricultural ecosystems, food industries and consumers will be no different than the effects of growing, processing and eating new cultivars from traditional breeding.

However, in New Zealand we have legislated such that breeding using genetic modification is a difficult option. However, a recent scientific review from the University of California, Davis has reported that the performance and health of food-producing animals consuming genetically engineered feed has been comparable to animals consuming non-genetically engineered feed. The review study also found scientific studies have detected no differences in the nutritional make-up of the meat, milk or other food products derived from animals that eat genetically engineered feed.

Regulation of science and technology

Governments need to clarify what they are regulating for (safety and environmental impact) and what they are leaving to consumers to decide (informed choice). The challenge is to ensure that objective risk drives regulation and risk perception, informed or otherwise, drives choice.

For genetically modified crops and forages the balance of evidence strongly suggests that:

- The technology is not innately hazardous
- The risk is the same for an organism expressing a particular trait, irrespective of whether it is created by genetic modification or conventional breeding
- Some applications may produce negative environmental impacts, but these are identified during the regulatory process, and
- The overall impacts of conventional intensive agriculture are as great, or greater than, those from genetic modification.

The regulatory system is partial, ineffective, expensive and not wholly evidence-based, yet changes would be strongly opposed. In 2012, Wang and Bouton identified three aspects that need to be considered in the regulatory process:

- Regulation of transgenics should be based on the risks posed by the features of the product, not the process of breeding
- Gene flow within and between populations is an essential feature of out-crossing species such as many forage, turf and bioenergy crops because of their natural self-incompatibility. A major focus in risk assessment research on these species should therefore be placed on the consequences of transgene flow
- Forage, turf and bioenergy species do not enter the food chain directly, or in some cases at all, and the regulatory hurdle needs to reflect this lower risk situation.

So is New Zealand missing out on the opportunities presented by genetic engineering? Our farmers are clearly limited in international markets by not having the advantages of the production efficiencies that are offered by genetically modified crops in other countries reliant upon exporting food. However, the New Zealand food industry and consumers already benefit from the importation of products from genetically modified crops. Yet according to the New Zealand Food Standards website a total of 83 genetically modified events in nine crops are approved for food use in this country.

Concluding comment

Because plant breeding is a valuable and necessary part of improving agricultural production and productivity, breeders continue to seek ways of improving germplasm performance through:

- Increasing the genetic variation available for selection
- Improving methods of breeding and the capture of beneficial genes into populations, and
- Learning with end-users how to manage elite genetic germplasm to gain the best outcomes of increased production and profitability.

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KEVIN OLD AND PETER NUTHALL

Succession on New Zealand farms

There is a strong belief that few farmers think well ahead on matters of farm asset succession. Nor do they take action, despite most professionals recommending that plans should be developed early in the life of a farm after proper consultation with the likely stakeholders and professionals. This article reports on farmers' current thinking about succession and progress in implementing succession plans.

Succession is very much a family affair because by far the majority of primary producing farms are owned by families, with sole traders, partnerships, family trusts and private company situations the dominant ownership structures. Eighty three per cent of farm assets are held this way – for more information see our article in the March 2015 issue of this Journal.

Plans and progress in succession

Most people assume succession takes place on retirement but it is also a factor when a farmer, for whatever reason, leaves a farm to take up another challenge. **Table 1** contains data on intentions for such cases. Succession plans should clearly be in place at an early stage in the history of a farm for a range of reasons, one of which is untimely injury or death because the risk is always there. Similarly, changes in family circumstances, such as divorce and separation, occur as do changes in career and other motivations of both farmers and heirs.

Table 1 shows most farmers (46.3 per cent) do not intend to leave the farm. Around 32 per cent expect to pass the farm on to heirs, with close to 22 per cent expecting to sell up and move on. Of particular note, it can be assumed those who do not intend to leave the farm have made a succession decision, leaving over 68 per cent (100 minus 32) of respondents having a succession matter for someone to deal with.

Table 1: Intentions of farmers leaving current farm before retirement – percentages of all farmers

Intention	%
Sell up and invest off-farm	12.3
Sell up and purchase another farm	3.0
Sell up and gift some or all to heirs	6.5
Pass farm to heirs	31.9
Do not expect to leave farm	46.3

Despite all these factors it is clear that many farmers, and their co-owners and advisors, think they will complete their intended time on the farm with succession plans being put into place almost instantly. **Table 2** presents the data on how long farmers have been passing assets on to intended recipients. Well over half (54.7 per cent) of the respondents had not started, with a further 24 per cent having only started in the last decade.

Table 2: Number of years since first starting to pass assets on to chosen heirs

No. of years since starting to pass on assets	% of the sample in each category
0 years	54.7
1–5 years	9.1
6–10 years	14.5
11–15 years	8.1
16–20 years	5.7
21–25 years	2.9
25–30 years	2.4
>30 years	2.6

Even older farmers are backward in acting. **Table 3** shows nearly half (47.72 per cent) of farmers 46 years and older have not begun to transfer their assets and 10 per cent over 65 have not yet started.

Table 3: Number of years since first starting to pass assets on to chosen heirs by age of respondent – percentages of the total sample

No. of years since asset transfer started	Age 26–35 years	Age 36–45 years	Age 46–55 years	Age 56–65 years	Age >65 years
0 years	1.03	6.02	19.97	18.06	9.69
1–10 years	0.15	1.91	7.05	7.63	6.90
11–20 years	0.15	0.59	3.08	5.14	4.85
21–30 years	0.15	0	0.73	0.88	3.38
>30 years	0	0	0.15	1.03	1.47

Not unsurprisingly, respondents above 65 years of age have the greatest mean years since starting to transfer assets. When analysing respondents' asset values, those with net assets worth between $5 million and $25 million have higher mean years since starting to transfer them than those with assets under this amount.

When the number of children per respondent is considered then those with two, three or four children appear to have started earlier than those with none, one or more than four. The respondents' level of education does not seem to have a marked effect on mean years since starting asset transference, as shown in **Table 4**.

Table 4: Relationship between years since starting asset transference and farmer age, farm net assets, number of children in the farm family and education level (cells give the mean number of years for each category)

Farmer age years	Mean years	Assets $ million	Mean years	No. of children	Mean years	Education level	Mean years
26–35	4.90	<5	5.03	0	4.59	Primary	5.00
36–45	2.49	5–10	9.39	1	4.93	Sec <=3 years	6.55
46–55	3.85	10–15	11.93	2	7.02	Sec >3 years	5.37
56–65	5.95	15–20	9.95	3	6.81	Tert <=2 years	7.30
>65	10.45	20–25	11.67	4	5.91	Tert >2 years	5.83
		>25	1.78	>4	3.38		

The survey results show that a staggering 68 per cent of respondents have not transferred any assets to their chosen heirs, while only 3.6 per cent have transferred over 90 per cent to them, as shown in **Table 5**. It is clear that the vast majority of many succession plans are not being implemented.

Table 5: Percentage of sample falling into various current degrees of net asset transfer to chosen heirs

Ranges of asset transfer to chosen heirs –current % transfer	Percentage of total sample falling into each transfer % range
0%	68.3
0–10%	7.8
11–20%	2.7
21–30%	4.3
31–40%	3.0
41–50%	4.1
51–60%	0.6
61–70%	1.1
71–80%	2.6
81–90%	1.7
>90%	3.6

The survey results show that a staggering 68 per cent of respondents have not transferred any assets to their chosen heirs.

Children and the succession problem

Family size is clearly a major factor in succession. Families are tending to reduce in size, as shown in **Tables 6** and **7**, but most families have more than one child and many much more than this.

Table 6: Number of children in each farming family – percentage of total sample falling into each age range cell with the last two columns giving the average number of children per family in each range, and the percentage of the total sample represented in each row

Age range years	% with 1 child	% with 2 children	% with 3 children	% with 4 children	% with 5 children	% with >5 children	Average no. children	% of total sample
0–5	2.6	1.5	0.9	0.1	0	0	1.71	5.1
6–10	4.6	2.5	0.2	0	0	0	1.41	7.3
11–15	7.1	4.2	1.0	0	0	0	1.51	12.3
16–20	10.8	6.0	1.0	0.1	0	0	1.47	17.9
21–25	10.2	8.8	1.7	0.2	0.1	0	1.64	21.1
26–30	9.9	11.1	1.4	0	0	0	1.62	22.4
31–35	10.4	6.6	3.0	0.2	0	0	1.66	20.2
>35	4.7	8.7	6.0	2.6	1.0	0.7	2.58	23.7

Note: The last column adds to more than 100 per cent as families' span age ranges.

Clearly two to three children is a popular family size, with the mean numbers shown by respondent age and net asset, respectively, below in **Table 7**. Not unsurprisingly, older respondents tend to have larger families. Also fortuitously, or perhaps by design, those with higher asset levels tend to have larger families. If assets are to be divided evenly a larger numerator is helpful.

Table 7: Mean number of children in a family according to the respondents' age and asset level

Age range years	Mean no. of children	Asset range $ million	Mean no. of children
26–35	1.47	<5 m	2.25
36–45	2.00	5–10 m	2.67
46–55	2.34	10–15 m	2.41
56–65	2.33	15–20 m	3.17
>65	2.38	20–25 m	3.00
		>25 m	2.73

Also relevant for the survival of the family farm is the number of children interested in becoming farmers. **Table 8** clearly highlights that most respondents have at least one child who is interested in becoming a farmer. It is noted, however, that 38.9 per cent of the sample had no children with a serious interest in farming.

Table 8: Offspring interest in becoming farmers – percentage of sample and for each age grouping the mean number interested in farming

No. of children interested#	% of sample	Mean 1–5 years	Mean 6–10 years	Mean 11–15 years	Mean 16–20 years	Mean 21–25 years	Mean 26–30 years	Mean 31–35 years	Mean >35 years
1	30.3	0.40	0.60	0.72	0.79	0.86	1.12	1.09	0.71
2	17.5	0.50	1.053	0.91	0.89	1.13	1.08	0.91	0.99
3	5.1	0.83	1.00	1.25	0.87	1.43	0.73	1.08	1.11
4	1.2*	0	0	0	1.00	3.00	0	1.50	0.98
5	0	0	0	0	0	2.00	0	0	1.86
>5	0	0	0	0	0	0	0	0	1.33

Number from each family expressing an interest in farming, according to the respondent.

* This 1.2 covers not only families with four children, but also families with more than four. Note: This column adds to less than 100 as it does not include the 38.9 per cent of farm families with no children interested in a farming career.

Plans for divesting assets

Whether acted on or not, most farmers do have ideas about what they intend to do over succession and **Table 9** provides some of this data. The vast majority of farmers across all farm types propose to pass the farm on to the next generation.

This is also the case when the data is analysed by respondents' age group. Also when grouped by respondents' asset level, most intend to pass the farm on to their children, except for those with assets over $25 million where a little under half of the respondents expect to transfer them to the next generation.

Table 9: Mean percentage of net assets proposed to be passed to the next generation and farmer's spouse according to farm type, farmer age and net asset level

Farm type	% to next generation	% to spouse	Age band	% to next generation	% to spouse	Asset band	% to next generation	% to spouse
Sheep	78.38	70.14	26–35	90.00	83.33	<$5 m	78.98	75.32
Ext sheep	84.97	70.56	36–45	79.12	67.00	5–10 m	85.87	53.88
Deer	96.67	77.50	46–55	87.66	73.93	10–15 m	85.45	68.08
Cattle	73.93	80.40	56–65	76.24	67.82	15–20 m	90.00	53.33
Dairy	82.55	67.95	>65	78.47	74.21	20–25 m	97.80	13.00
Other animal	100.00	n/a				>$25 m	47.50	50.00
Fruit/viticulture	88.12	90.67						
Cash crop	74.09	47.00						
Flowers/ornamental	100.00	100.00						
Vegetables	100.00	100.00						
Other	72.74	61.94						

Note: The total divided between the next generation and spouse usually exceeds 100 per cent because the plans allow for a surviving spouse in the first instance.

Similarly, most farmers have considered their possible action where their family involves more than one child. The children's intention regarding farming will influence these thoughts. The matter of equity between siblings is high among respondents' responses, with just under half (47.3 per cent) suggesting they would pass on the assets equally among children, even if it meant selling the farm. A further 19 per cent plan to pass the farm on to one child, but expect that child to compensate other siblings. Nineteen per cent of respondents intend to give equal shares to those children wishing to farm. Less than one per cent of respondents wished to pass on an unequal share to their children, as shown in **Tables 10** and **11**.

Table 10: Choice of succession possibility for farmers with more than one child

Option	% of sample using each option
Pass on assets equally even if need to sell farm	47.13
Pass on to one child expecting this child to compensate the others	18.79
Give equal share to each child wanting to be a farmer	19.27
If more than one child interested, pass to one and expect them to give a share of the income to the other(s)	7.32
Pass on an unequal share to the children	0.64
Miscellaneous	1.43
Not decided	5.41

Table 11: Percentage of the total sample numbers in each row (representing number of children) with respect to the farmer's choice of distributing assets where there is more than one child

No. of children in the farm family	*Pass assets equally	*One child on farm	*Equal shares of farm to interested children	*Give to one who pays others	*Unequal payments	*Misc	*Undecided
0#	16.85	4.35	6.52	2.17	1.63	1.63	0.54
1	23.33	16.67	6.67	3.33	3.33	0	0
2	42.54	17.13	19.34	5.52	5.52	1.66	0.55
3	43.82	20.22	16.85	7.12	4.87	0	0.37
4	50.00	12.00	19.00	9.00	5.00	1.00	1.00
5	27.59	24.14	24.14	6.90	3.45	6.90	0
>5	42.86	7.14	7.14	7.14	7.14	0	0

* Miscellaneous – see Table 10 for a full description of the headings listed in the rows.

Intentions when, and if, have children.

When there is more than one child, looking at the farmers' net assets and choice of asset distribution, in the $15 million to $20 million group there is a markedly higher (58 per cent) intention to pass assets on equally, even if it means selling the farm to do so. It is likely at these asset levels that these respondents have a number of farms, making equality between siblings simpler, as shown in **Table 12**.

Table 12: Percentage of the total sample numbers in each row (representing the farm's net assets) with respect to the farmer's choice of distributing assets where there is more than one child

Asset level $ million	*Pass assets equally	*One child on farm	*Equal shares of farm to interested children	*Give to one who pays others	*Unequal payments	*Misc	*Undecided
<5	37.79	16.08	11.82	5.23	5.04	1.16	0.77
5–10	39.68	9.52	24.60	7.14	2.38	0.79	0
10–15	29.41	29.41	20.59	8.82	2.94	0	0
15–20	58.33	16.67	0	8.33	0	0	0
20–25	28.57	28.57	28.57	0	14.29	0	0
>$25	36.36	0	27.27	0	0	9.09	0

* See Table 10 for a full description of the headings listed in the rows.

Relating farmers' age groups with their intentions to distribute assets, while the differences are not great, as farmers get older there is a tendency towards sharing assets equally. However, relative to the children interested in farming, there is less interest in distributing assets by equal shares. Further, distributing unequal shares increases with farmer age, as shown in **Table 13**. These latter views probably relate to the older generation.

Table 13: Percentage of the total sample in each row (representing the farmer's age) with respect to the farmer's choice of distributing assets where there is more than one child

Farmer age (years)	*Pass assets equally	*One child on farm	*Equal shares of farm to interested children	*Give to one who pays others	*Unequal payments	*Misc	*Undecided
26–35	5.88	29.41	23.53	0	5.88	0	0
36–45	27.94	17.65	17.65	2.94	7.35	0	1.47
46–55	33.33	13.65	20.08	5.22	4.02	1.61	0.80
56–65	43.25	12.70	11.51	5.55	4.76	1.19	0.40
>65 yrs	39.15	16.51	11.79	7.55	2.83	0.94	0

* See Table 10 for a full description of the headings listed in the rows.

The survey data suggests that the vast majority of farmers intend to pass their assets on to their children, but not a lot has transpired. The next section considers this and other factors.

Help used in setting up and running governance and succession systems

It is clear that many farmers do have not formally organised succession systems, but many have at least sought advice and **Table 14** provides the background information. Note that this data covers both succession and governance. Information dividing the hours into the separate activities was not available. It can be seen here that professional advisors are used very sparingly by respondents, with the vast majority using them for between zero to two hours per annum on succession and governance advice. This is in stark contrast to respondents' 'trusted person' and 'company representative' who are used far more often.

Table 14: Hours per annum spent with various advisors on succession and governance plans and arrangements – percentages of farmers using a particular type of advisor for specified times (range of hours)

Type of advisor	0–2 hrs	2–4 hrs	4–6 hrs	6–8 hrs	8–10 hrs	>10 hrs
Farm consultant	62.6	6.1	10.2	0.7	10.9	9.5
Accountant	52.8	15.7	12.9	2.8	7.5	7.5
Lawyer	66.8	6.3	12.4	1.1	7.8	3.3
Business consultant	75.8	4.4	4.4	2.2	6.6	6.6
Banker	61.9	4.8	14.3	2.3	14.3	2.4
Company representative	40.0	20.0	0	0	20.0	20.0
Trusted person e.g. relative	5.0	0	5.0	10.0	35.0	40.0

The average hours per annum spent on succession and governance advice again highlights the importance of the trusted person in succession and governance advice. This is at nearly four-fold the hours compared to the next highest used options, company representative and farm consultant, as seen in **Table 15**.

Table 15: Average hours of use of various advisor types on succession/governance and farm advice

Type of advisor	Average hours p.a. on succession/ governance	Average hours p.a. spent on farm advice
Farm consultant	7.01	20.74
Accountant	4.94	5.68
Lawyer	3.60	2.95
Business consultant	4.13	7.64
Banker	3.40	8.75
Company representative	7.40 (n=5)*	13.56 (n=16)*
Trusted person e.g. relative	31.95 (n=20)*	50.59 (n=27)*

* The starred figures are the number of farmers answering the question and are presented where the numbers were low.

Table 16 breaks down by respondents' net assets their use of advisors on succession and governance matters. It is clear that more affluent respondents tended to use professional advisors to a far greater extent than those with less net wealth. Of note is the very high use of the trusted person by respondents with net assets in the $10 million to $15 million asset range, at over three times the use by respondents in other ranges.

Table 16: Use of various advisor types on succession/governance matters according to farm's net asset investment – average hours per annum used on each type

Asset range $ million	Farm consultant	Accountant	Lawyer	Business consultant	Banker	Company representative	Trusted person
<5 m	7.46	4.20	2.41	1.23	1.67	11.33	8.17
5–10 m	6.78	4.55	5.19	11.43	4.67	1.50	79.50
10–15 m	5.45	7.60	6.61	1.80	10.00	n/a	26.00
15–20 m	3.50	5.40	3.14	n/a	n/a	n/a	8.00
20–25 m	6.67	23.17	9.33	5.00	n/a	n/a	10.00
>25 m	12.20	12.43	11.43	9.33	0.50	n/a	20.00

Note: Where n/a is given this usually means no answer has been provided by the small number of farmers falling into the category or no farmers are in the category.

Satisfaction with current succession plans

Both farmers with formal succession plans and those without still feel relatively happy about the current situation. Over 70 per cent of respondents with zero to three children are either very happy or reasonably happy with their succession plans. Even those with four or five children mainly rate being reasonably or very happy with their plans. However, those who are very happy tend to drop as the number of children increases. Those with greater than five children are perhaps understandably far more ambivalent about their succession plans compared to those with less children. It is also clear the number of respondents who are most unhappy with their succession plans rises with the number of children.

Table 17: Degree of happiness with succession plans with respect to the number of children in the family – column percentages

Happiness with succession plans*	0 children	1 child	2 children	3 children	4 children	5 children	> than 5 children
Very happy	52.71	52.00	42.50	35.40	36.14	32.00	22.22
Reasonably happy	17.83	24.00	28.12	24.78	19.28	32.00	11.11
Ambivalent	22.48	16.00	18.12	25.22	26.51	20.00	55.55
Unhappy	4.65	0	5.00	7.96	12.05	8.00	0
Most unhappy	2.33	8.00	6.25	6.64	6.02	8.00	11.11

* The row descriptions are paraphrases of the originally rated statement – see F10 of the questionnaire available from the author.

The data shows most farmers do not have a formal succession plan, but it does appear they are not worried about this situation. Is this a head in the sand approach, and if so why?

Perhaps unsurprisingly it appears that both younger (less than 35-year-old) and older (greater than 65-year-old) farmers are happier with their plans than those in the middle age groups. Nevertheless, across all age groups the vast majority of respondents are either very or reasonably happy with their succession plans. Indeed, the highest percentage of those in the unhappy or most unhappy group amounted to less than 18 per cent, with only just over five per cent of those over 65 years old falling into these two categories, as shown in **Table 18**.

Table 18: Degree of happiness with succession plans according to the farmer's age – column percentages

Happiness with succession plans*	<35 years	36–45 years	46–55 years	56–65 years	>65 years
Very happy	46.15	28.85	28.71	42.36	57.30
Reasonably happy	23.08	34.61	23.92	24.14	19.66
Ambivalent	23.08	19.23	29.66	21.18	17.98
Unhappy	0	7.69	10.53	5.91	2.81
Most unhappy	7.69	9.61	7.18	6.40	2.25

* The row descriptions are paraphrases of the originally rated statements – see F10 of the questionnaire.

The data shows most farmers do not have a formal succession plan, but it does appear they are not worried about this situation. Is this a head in the sand approach, and if so why? Or are they genuinely content with the status quo? Anecdotally, it is apparent that not all succession arrangements work out to the satisfaction of the participants. Indeed, the authors were contacted by a number of people after the survey was sent outlining the (often quite sad) outcomes of their succession stories.

Concluding comments

The data and analysis clearly show that although New Zealand farmers are on the whole happy with their succession arrangements they are not actively planning and/or taking much professional advice. If farmers do share their assets equally among children, many of their heirs will not receive an adequate farm-based income or be able to continue farming. Farmers appear reluctant to engage in succession planning. Somehow farmers need to be shocked into considering succession and making plans. Associated ownership arrangements also need to be carefully organised. Currently, most farmers have simple sole owner or partnership arrangements.

Anecdotal evidence suggests that any plans made must be flexible enough to allow for changing circumstances and wishes. Some horror stories exist where, despite earlier family conferences providing agreement, feelings have changed causing plans to become inappropriate. In some cases it was not possible to make changes, leading to results that did not seem to suit any of the participants and certainly were not the wishes of the farmers passing their assets on.

Most farms in New Zealand continue to be family operations. It is important that a great deal of early thought is put into their succession planning. The wants and desires of all those involved need to be understood and it is likely that every situation will be different. These plans should also remain flexible as people's thinking changes over time and circumstances change – children change their minds on careers, most get married, some divorce and there are sometimes family rifts. These and other problems may undermine the plans put in place. Consequently, in most cases professional assistance is likely to assist both with mediation and with setting up appropriate financial and legal systems.

The information for this article comes from a farm survey carried out over the latter part of 2013, with the questionnaire being first mailed in June of that year. The New Zealand wide survey was sent to a random stratified sample of over 2,200 commercial farmers across regions, farm types and sizes. Follow-up mailings were sent to non-respondents resulting in a good response rate of 36.1 per cent, highlighting the farmers' interest in the topics covered. Comparison to Statistics NZ data suggests that the distribution of respondents was reasonably representative by farm type and size.

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MIKE JOY

Water quality issues in New Zealand – stressed ecosystems and future solutions

This is the first of a two-part article by Mike Joy about water quality. It outlines the increasing strain on freshwater ecosystems, gives a definition of water quality, discusses freshwater decline in detail and suggests future solutions.

Stress on freshwater ecosystems

Freshwater ecosystems in New Zealand have been under considerable and increasing stress since European colonisation. The draining of 90 per cent of wetlands and the removal or alteration of a similar amount of indigenous vegetation cover has placed much strain on the health of freshwaters. These changes have wrought immense impacts on freshwaters through the loss of the crucial hydrologic and biological functions performed by intact wetland and forest ecosystems.

These impacts have been exacerbated by the more recent intensification of farming with the concomitant addition of excess nutrients and sediment to water, as well as the effects of urbanisation and the introduction of exotic species. The cumulative impacts of all these changes are revealed by declining water physicochemical measures and the biological status of freshwater ecosystems. The most obvious impacts are revealed by biological indicators, with 74 per cent of the native freshwater fish species listed as threatened, and 90 per cent of monitored lowland waterways and 62 per cent of all waterways failing bathing standards.

Lowland lakes are under immense pressure, as revealed by the 44 per cent of monitored lakes that are now eutrophic or worse, and these are mostly the lowland lakes with pastoral catchments. The legislative response from central and local government to the obvious freshwater decline has failed to halt or even reduce the rate of deterioration. In contrast, government initiatives to weaken protection and increase farming intensification mean there is no chance of improvement and further decline will be the future for New Zealand freshwaters.

What is water quality?

The term 'water quality' suggests to many some kind of comprehensive assessment of freshwater condition encompassing aspects of habitat, biodiversity and freshwater health and integrity. However, in reality it is more of a managerial than an ecological assessment. Consideration of the components currently used to assess water quality, and the way they are measured, reveals they are more closely related to ease of sampling and presentation of data than any genuine representation of waterway condition.

Water quality assessment, as prescribed by the Ministry for the Environment and measured by regional authorities, generally consists of a suite of snapshot monthly samples of five physicochemical measures and occasionally some minimal biological assessment. The physicochemical factors are suspended sediment, nitrogen, phosphorus, temperature and dissolved oxygen. The biological assessment is reported using macro-invertebrate metrics such as the macroinvertebrate community index (MCI) and visual or biomass assessment of periphyton abundance. Assessment of waterway suitability for bathing and human health is made by measuring faecal bacteria and clarity.

Remarkably this water quality assessment fails to measure the following really important factors – freshwater ecosystem function, habitat quality and biodiversity. What is possibly worse is that this limited set of measures are collected as one-off snapshot samples when it has long been known that the parameters become progressively more variable as impacts accumulate in freshwater systems. For example, oxygen levels are known to fluctuate through diurnal cycles due to algal photosynthesis and these fluctuations become more extreme as nutrient levels increase with eutrophication.

Another critical failing is the use of median and mean values for setting limits and presenting water quality measures to the public. These numbers simplify description and are popular with managers, but they have no biological realism. The median or mean values, for example, of temperature or oxygen are biologically irrelevant because it is the extremes that are crucial.

ALGAL BLOOM. This photo from the Manawatu River shows what nuisance filamentous algal bloom looks like. The covering of a river bed has a large impact on the fish and invertebrate life and makes fishing and swimming virtually impossible. Perhaps the biggest impact is the alteration of the oxygen availability for the fish and invertebrates. Blooms like this cause daily fluctuations that can be lethal as they become more extreme.

From a biological perspective, if temperature exceeds the threshold lethal limit or oxygen goes below it (even if it is just one per cent of the time) then it is fatal. What the average level was is inconsequential.

Importantly, many of the impacts on freshwater biology are not directly related to the water quality parameters that are measured, rather the biological effects are secondary. For instance, when nutrients in rivers increase fish are not affected directly at first, although at very high levels these nutrients are toxic. However, initially the ensuing increase in algal growth can – if other conditions are conducive – lead to extreme fluctuations in oxygen availability. As a regional example, oxygen saturation fluctuates enormously in parts of the mid and lower Manawatu River where the catchments are dominated by agriculture.

At one monitoring site in the river the oxygen saturation levels in summer vary from less than 40 per cent in the early morning to more than 140 per cent in the late afternoon of the same day. These extremes (both low and high) are potentially lethal for all stream life, or at least harmful. However, because guidelines and measurements are based on snapshot sampling this diurnal variability is overlooked, and the detrimental consequences are therefore generally not apparent to resource managers.

The other water quality parameters – nutrient levels, pH, suspended sediments and temperature – also vary in degraded systems. However, unlike oxygen the changes are not always diurnal but are also in relation to flow and biological in-stream processes. For example, the bulk of the pathogens and phosphorus entering flowing systems occur during flood events, and both phosphorous and nitrogen levels can vary as these nutrients are taken up and released by in-stream plant life. Assessing such variability using one-off snapshot sampling is obviously not credible.

What is not measured?

Crucially, other key indicators of ecological decline are not measured at a national scale, including physical alteration of habitat by deposited sediment, which infills interstitial spaces in the substrate that are known to be crucial important habitats for fish and invertebrate life. As well as the physical in-stream engineering of rivers for

flood control using heavy machinery, and the associated confining of rivers within stop-banks, there is the loss of habitat to migrating fish and the blockage of downstream passages to complete life-cycles caused by dams for hydro-electricity and irrigation.

Freshwater decline

As mentioned, New Zealand's freshwater ecosystems have undergone significant and obvious deterioration. This has occurred physicochemically and ecologically over the last few centuries, but especially in the last few decades. The decline is revealed in many ways, including severe reductions in biodiversity as well as by declining physicochemical measures taken at most lowland waterways. One of the starkest indications of the extent of the deterioration in freshwater ecosystem health is the fact that New Zealand now has proportionally more threatened freshwater fish species than almost any country globally, as noted by the International Union of Conservation of Nature (IUCN) in 2010.

New Zealand now has proportionally more threatened freshwater fish species than almost any country globally.

In global terms the decline of freshwater biodiversity in New Zealand is relatively recent. However, it mirrors the decline worldwide where the symptoms and causes of deterioration are similar but have generally occurred over much longer time periods. The primary reasons for decline in New Zealand have been the unrestrained agricultural intensification and indigenous vegetation clearance, with attendant increases in nutrients and sediment inevitably entering lakes, rivers and groundwater. These impacts are combined with those of urbanisation, damming of rivers and exotic species introductions. Unfortunately, apart from rare exceptions to protect a few iconic waters, there is little indication that the limited government initiatives to halt this erosion in the health of freshwater ecosystems have had any net effect.

The reasons for decline in this country and their impacts on freshwater biodiversity are similar to those occurring globally. These pressures include eutrophication, habitat loss and population isolation caused by the damming of rivers, habitat destruction, species invasions and introductions, over-harvesting and climate change. This list of pressures is not comprehensive, but it does include the major impacts. However, ascertaining how they interact, particularly the question of whether they are additive or multiplicative, is difficult to assess.

In New Zealand it is clear that the decline in the health of freshwaters is dominated by agricultural impacts, primarily excess sediment, phosphorus and nitrogen, as well as faecal pathogens. The major contemporary cause of the deterioration in the health of New Zealand's lakes, groundwater, rivers and streams is therefore associated with increases in nutrients, mainly nitrogen, from the virtually uncontrolled intensification of dairy production. This escalation in intensity is caused by a farming system based on a strategy of low-cost production which, in the absence of any meaningful leadership from central government, has inevitably led to many unsustainable practices.

The main issue for freshwaters from this intensification is diffuse-source as opposed to nutrient and pathogen pollution of waterways from the pasture-based livestock farming model. This diffuse pollution is the run-off or seepage through soils of nutrient-laden water and urine due to high stocking rates. The remarkable stocking rates now found in New Zealand have been achieved by the increasing use of off-farm feed supplements like palm kernel and fossil fuel-derived nitrogenous fertiliser and imported fossil phosphate.

As an example of the magnitude of intensification of dairy farming in New Zealand, between 1990 and 2010 the number of dairy cows in the South Island increased seven-fold, with obvious substantial negative impacts on the quality of lowland streams. During the same period the number of cows in the Waikato River catchment increased by 37 per cent, and over that period nitrogen levels in this river increased by 40 per cent and phosphorus by 25 per cent. Dairy cow numbers reached 6.5 million in 2012, and given that each cow excretes more waste than 15 humans, the human-equivalent population of New Zealand is more than 90 million. The actual human population of this country is less than 4.5 million, so these statistics put the relative volume of human versus animal wastes into perspective.

Future solutions

The stick

The precedent, and an example for reducing farming intensity and therefore impacts on freshwater, has been set with cap and trade limits on nutrient loads to Lake Taupo. This is just one of a range of options, but it does give a model for the type of approach that could be adopted nationally. Another approach aims more at matching land use intensity to soil type as in the Horizons Regional Council One Plan. Another potentially positive change is the 2010 Waikato-Tainui agreement made to protect and improve the health of the Waikato River resulting from a claim over the river taken to the Waitangi Tribunal by Tainui-Raupatu.

Under this co-management agreement, Tainui-Raupatu iwi have had their vision and strategy for cleaning up the Waikato River legislated. The vision statement is aspirational and can be summarised by this statement

TORRENTFISH. These are another of our threatened native fish, and are unusual in that they have no close relatives in freshwaters and are almost only ever found in the shallow riffle zones of larger rivers. Torrentfish are particularly vulnerable to engineering works and stop-banking of rivers as this removes the rifflebars they prefer.

from the report: 'Our vision is for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come.'

As an example of just how far reaching this vision is one of the objectives (k) states: 'The restoration of water quality within the Waikato River so that it is safe for people to swim in and take food from over its entire length.' But to achieve these aspirational objectives substantial changes would be required to land use in the Waikato River catchment. However, at the time of writing, four years after the enactment of this legislation there is little sign of any changes to the rules necessary to achieve the goals of this vision and strategy. Nevertheless, this aspirational vision may yet lead the way for the changes in land use required to ultimately improve water quality in New Zealand.

On-farm the only solution for protecting the natural capital of New Zealand, while at the same time producing large quantities of low-value milk powder or any other agricultural product, is simply to 'close the loop' and ensure that nutrients and soils stay on farms and are cycled within the system and that fossil fuel use for fertiliser or energy is reduced. Examples of this truly sustainable style of farming are occurring in North America and Europe, and these farms can be used to show the way in New Zealand.

One way to begin to move toward sustainability can be seen with the adoption of covered feed pads where the troublesome bovine urine can be collected and spread so that pasture can take it up. This is instead of it leaching through soils and eventually polluting waterways. Also, if the urine is put on evenly over a larger area then plants can take it up before it disappears past the root zone. The downside to this environmental gain is the fact that it is capital intensive, and given the already high levels of debt on farms in New Zealand this will be problematic.

The future for freshwater health in New Zealand is bleak, as there is no prospect of any polluter-pays legislation and the lag times for nutrients entering waterways are often decades. Even if moves to cap and reduce nutrient loads were immediate and applied nationally, water quality will therefore continue to decline for some time. If the polluter-pays principle had been

KOARO. One of the adult whitebait species, the koaro is on the threatened species list. They are not tolerant of pollution and are generally found in clean, fast-flowing bouldery waterways and can climb enormous waterfalls and travel inland long distances from the sea.

applied in New Zealand some decades ago, as promised at the Rio Summit in 1992, then the massive intensification of dairy farming would likely not have occurred and increases in profit would instead have come through adding value or diversification.

The hands-off approach over the last two decades has led to a huge overshoot of the carrying capacity of soils and freshwaters and the withdrawal from this situation will be difficult and expensive. On top of these failures to limit intensification and the inevitable pollution, central and local government are now involved in funding and promoting irrigation schemes that will predictably increase nutrient loadings on freshwater systems.

This drive for more agricultural production through irrigation has seen moves by central and local government to massively increase nutrient allowance in waterways. Two justifications are being used for this increase; one is that by controlling just one of the two nutrients required for algal proliferation (nitrogen and phosphorus) they can allow excessive levels of the other without impacts occurring. The fatal flaw in this limiting nutrient scenario is that in reality the occasions when growth is limited by the lack of one nutrient only actually happen in rare extreme cases, due to the inability to control other sources outside of the management area.

In any case, the risk of taking this approach is that allowing the build-up of either nutrient will set up the potential for major algal blooms and their resulting impacts. The second justification for relaxing limits is to use the toxicity level of nitrogen rather than the level at which it causes ecosystem-wide impacts. The widely accepted level in Australasia for the point at which nuisance algal growths occur is around half a milligram of nitrogen per litre, whereas the level where toxic effects occur is close to seven milligrams. Both justifications for weakening limits have little or no scientific legitimacy, but seem to have been accepted by many in the industry through some clever public relations work and a lack of independent commentators.

Until we put some kind of cost in the form of a charge on polluters, or pay a premium on nitrogen efficiency, we are effectively incentivising pollution.

Ultimately, the clean green image and the requisite clean green reality are crucial to the economic and environmental future for all New Zealanders, especially farmers. Thus, the deterioration of the state of this country's environment should therefore be a concern for everyone.

The carrot

We must immediately cost the impacts and value the gains of stopping the decline. It is clear that if the externalities of dairy farming in New Zealand are valued they would likely match or even exceed the revenue. Until we put some kind of cost in the form of a charge on polluters, or pay a premium on nitrogen efficiency, we are effectively incentivising pollution. The European experience has shown that strong legislation and enforcement can lead to great improvements, but there is an alternative to wielding a big stick and that is to dangle a carrot instead. We must start measuring nitrogen efficiency and rewarding the most efficient and penalising the least.

The measure of nitrogen efficiency is simple and easily calculated; it is the ratio of kilograms of milk solids produced to the amount of nitrogen leached. These numbers are already available to all dairy farmers so could be implemented immediately. Milk companies could pay a premium to the most efficient and regional councils could give rates reductions to these farmers too. In both company and regional council examples, this could be fiscally neutral by taking from the bottom third and giving to the top third.

Summary

The deterioration in freshwater health in New Zealand progressed through the 20th century but accelerated in the last few decades. In these decades many European countries implemented regulatory changes that in some cases halted the decline, and even resulted in improvements in water quality in some. New Zealand has ignored this and continued with unconstrained intensification of farming driven by exponential increases in fertiliser use and the importation of stock feed. The relationship between land cover (a surrogate for land use) and fish communities and river nutrient and pathogen levels reveals the obvious causes of the decline. The decline in fish biodiversity is also related to the loss of habitat, a result of barriers to migration such as hydroelectric dams and weirs and the draining of more than 90 per cent of wetlands, mainly for agriculture.

In 1991 the Resource Management Act was passed into legislation. It encompassed the lofty ideals of a generation of New Zealanders committed to a healthy and environmentally sustainable future. Sadly, the work of the authors of the Act proved futile because over the following two decades it was systematically diluted by a lack of enforcement and then later weakened through the Resource Management Simplifying and Streamlining Act 2009. Further proposals are now being considered to further weaken the protection intended by the Resource Management Act.

This weakening of the Resource Management Act combined with a failure to address the most pervasive impact on water quality (the intensification and industrialisation of dairy farming) has in part resulted in New Zealand's slide down to the lowest levels of environmental performance globally. The Bradshaw study of 2010, based on a suite of measures including fertiliser use, biodiversity loss, marine captures, water quality and more, ranked New Zealand around 130th of 180 countries.

This weakening of the Resource Management Act combined with a failure to address the most pervasive impact on water quality (the intensification and industrialisation of dairy farming) has in part resulted in New Zealand's slide down to the lowest levels of environmental performance globally.

The only indication of a future move to improve water quality in New Zealand is the involvement of Maori in freshwater management (the Waikato co-management example) and the economic value of tourism leading to moves to protect Lake Taupo by reducing dairy farming intensity. However, while this co-management has been mandated there is little evidence of changes in regional plans to meet the aspirations.

The conflicting needs of agricultural intensification, biodiversity conservation, sport fisheries management and urban spread have created many pressures on water resources. These show no sign of abating – in fact all are increasing. Despite the many unequivocal signs of the deterioration of freshwater from intensification of farming, the government is backing further intensification, mainly of dairy farming, through irrigation in drier areas. Consequently, impacts on freshwater biodiversity will inevitably accelerate. Undoubtedly the combination of climate change, agricultural intensification and further urban spread will have very serious consequences for freshwater biodiversity in New Zealand.

The future requires that we must either put a cost on pollution or a premium on not polluting, we must farm for profitability not for capital gain, and that we immediately begin to phase out the use of fossil fertilisers and imported fertilisers and feed.

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SEAN BEVIN

Regional dimensions of the New Zealand dairying industry

Much of the economic commentary about the dairy industry in New Zealand is usually concerned with its overall contribution to the national economy and its performance on the world stage with export returns. This is understandable, but it can overlook the important role that the different dairy production regions and districts play in the ongoing life of the industry.
These areas can be considered at the coal face and it is their collective performance that is the national dairy industry.

Land in dairy production

DairyNZ information for the 2013/14 production season indicates a total of about 1.7 million hectares of dairy land in New Zealand. The leading regional contributions to this total are, in order, Waikato (28 per cent of the total land area), Canterbury (15 per cent), Southland (12 per cent), Taranaki (10 per cent) and Northland (eight per cent). The remaining regions (Bay of Plenty, Hawke's Bay, Manawatu, Wellington, Top and West Coast South Island and Otago) account for the balance of 27 per cent of the production land. The Wellington and Hawke's Bay regions currently have the smallest areas of dairy land.

The regions that have seen significant increases over the past 15 years in the number of dairying enterprises include Southland with an overall approximate 530 (75 per cent) gain in enterprises since the year 2000, Canterbury with a 650 (70 per cent) increase, and Otago with a 250 (60 per cent) increase.

Dairy farms

Statistics NZ annual business demography survey results indicate a total of 16,089 dairy farming geographic units or business locations in New Zealand in February 2014. The largest regional contributions to this figure were, in order, Waikato (5,511 geographic units or about 34 per cent of the national dairying total), Taranaki 2,363 (15 per cent), Canterbury 1,591 (10 per cent), Southland 1,228 (eight per cent), Northland 1,154 (seven per cent) and Manawatu-Wanganui 1,120 (also seven per cent). The regions with the smallest number of dairy farming geographic units include Nelson, Gisborne, Marlborough and Hawke's Bay,

The regions that have seen significant increases over the past 15 years in the number of dairying enterprises include Southland with an overall approximate 530 (75 per cent) gain in enterprises since the year 2000, Canterbury with a 650 (70 per cent) increase, and Otago with a 250 (60 per cent) increase. The regions that have recorded an overall significant fall in dairying enterprises during the period include the wider Auckland region with a 430 (48 per cent) decline, Northland with a fall of 805 (41 per cent), Wellington with a fall of 145 (36 per cent) and Taranaki with a fall of 1,070 (31 per cent). Nationally, the number of dairying enterprises has fallen by 4,060 (20 per cent) since the year 2000.

Dairy herds, cattle numbers and milk production

The Waikato region has by far the largest number of dairy herds (4,042) in New Zealand (34 per cent of the national total). This is followed by Taranaki (14 per cent), Canterbury (nine per cent) and Northland (also nine per cent). Dairy cattle numbers are highest in Waikato at approximately 1.4 million followed by Canterbury at 0.9 million, Southland 0.6 million, Taranaki 0.5 million and Northland at 0.3 million. Together, these regions account for three-quarters of the total number of dairy cattle in New Zealand.

Over 2013/14, the leading regional contributions to the total value of milk produced in New Zealand during the year came from Waikato, Canterbury, Southland, Taranaki and the Bay of Plenty. The combined contribution of these areas was $11.7 billion (76 per cent) of the total value of all milk produced in the country during the year.

Dairy product processing and manufacturing enterprises

These enterprises are involved in either milk/cream processing, ice cream manufacturing, or cheese and other dairy product manufacturing. Enterprise numbers in New Zealand are by far the highest for the latter sector, representing 70 per cent of all businesses across the three sectors. Last year, regional business or enterprise numbers for the three sectors combined were highest for Auckland (30 per cent of the national total), Waikato (20 per cent), Canterbury (12 per cent) and Otago (eight per cent). Since the year 2000, the total number of dairy product ventures in these four areas has increased by 135 per cent, 41 per cent, 56 per cent and 183 per cent, respectively.

Regional employment in the dairy industry

Table 1 shows the regional spread of dairy farming and milk processing employment in New Zealand as at February 2014. The areas covered in the table represent the various local government/regional council authorities in New Zealand. Employment results for both dairy farming and dairy product manufacturing/processing are provided, along with the regional totals for both these industries combined.

The final column of the table indicates the proportion of all primary production and processing/manufacturing (direct wealth-creating industry) employment within each region that is attributed to the total dairy industry. Employment includes all full and part-time employees. The main points to note from the table are:

- Employment is highest in the dairy farming industry in the Waikato, Canterbury, Southland, Taranaki and Manawatu-Wanganui regions. Waikato accounts for 27 per cent of total national dairying employment, Canterbury 18 per cent and Southland 11 per cent.
- The leading regions for dairy product manufacturing or processing employment are, in order, the Waikato, Taranaki, Canterbury and Auckland. Together, these areas account for 71 per cent of total national employment for this industry activity.
- For the two dairying activities combined, Waikato accounts for 27 per cent of total national employment, Canterbury 17 per cent, Taranaki 11 per cent, Southland nine per cent and Manawatu-Wanganui seven per cent.

Table 1: Regional dairy industry employment in New Zealand 2014

Region	Dairying	Dairy Product Mfg	Total Dairy	All Primary/ Mfg Employment	Dairy % Primary/ Mfg Employment
Northland	1,590	590	2,180	10,510	20.7%
Auckland	410	1,450	1,860	77,660	2.4%
Waikato	7,390	3,320	10,710	40,590	26.4%
Bay of Plenty	1,520	470	1,990	21,740	9.2%
Gisborne	40	35	75	6,888	1.1%
Hawke's Bay	410	50	460	23,155	2.0%
Taranaki	2,580	1,820	4,400	14,160	31.1%
Man-Wanganui	2,190	700	2,890	19,665	14.7%
Wellington	520	50	570	16,740	3.4%
Tasman	420	140	560	8,065	6.9%
Nelson	12	3	15	3,613	0.4%
Marlborough	110	3	113	8,005	1.4%
West Coast	830	310	1,140	4,070	28.0%
Canterbury	5,120	1,700	6,820	49,810	13.7%
Otago	1,600	350	1,950	9,040	21.6%
Southland	3,080	670	3,750	8,360	44.9%
Total	27,822	11,661	39,483	32,2071	12.3%

Source: Statistics NZ's annual 'Business Demography' surveys

At the other end of the spectrum, the lowest employing regions for the overall industry are Nelson-Marlborough and Gisborne.

- The importance of the dairy industry in relation to the overall industrial base is highest for Southland where the industry accounts for 45 per cent of total primary production and manufacturing employment, Taranaki (31 per cent), West Coast (28 per cent), Waikato (26 per cent), Otago (22 per cent) and Northland (21 per cent). The industry is least important for Nelson-Marlborough, Gisborne-Hawke's Bay, Wellington and Auckland.
- The dairy industry accounts for 12 per cent of total national employment for the combined primary production and manufacturing industries.

Since the year 2000 regional employment growth in New Zealand in dairy farming has been highest for, in order, Southland, Canterbury, Otago, Hawke's Bay (off a low base in that year though), the West Coast and Manawatu-Wanganui. Employment growth has been lowest in the Auckland, Nelson, Marlborough and Wellington areas. Employment has more than tripled in Canterbury, Otago and Southland and more than doubled in West Coast South Island. Total North Island dairying employment has increased by 50 per cent while South Island employment has risen by 215 per cent. The North Island presently accounts for 60 per cent of total dairying employment in the country.

Local authority district profile

While examining the regional dimensions of the dairy industry in New Zealand, it is also useful to understand its more localised geographical distribution in terms of local authority districts throughout the country. Those districts with in excess of 1,000 people currently employed in dairy farming activity are Matamata-Piako, Waipa, South Taranaki, Ashburton and Southland. The districts with between 500 and 1,000 dairy industry employees are Whangarei, Kaipara, Hauraki, Otorohanga, Taupo, Rotorua, New Plymouth, Manawatu, Tararua, Selwyn, Timaru, Waimate, Waitaki and Clutha.

The districts with between 100 and 500 employees include the Far North, Auckland, Thames-Coromandel, Waitomo, Western Bay of Plenty, Opotiki, Hastings, Central Hawke's Bay, Stratford, Wanganui, Palmerston North, Horowhenua, Carterton, South Wairarapa, Tasman, Marlborough, Buller, Grey, Westland, Hurunui, Waimakariri, Dunedin, Gore and Invercargill.

Those districts which have recorded the highest numerical increases in dairy farming employee numbers over the 2000 to 2014 period have been Southland, Ashburton, Selwyn, Clutha, Timaru, Waitaki, South Taranaki, South Waikato, Waikato, Matamata-Piako and Waimate. Southland District dairy employee numbers have increased by 2,010 since the year 2000 and by 1,340 for Ashburton, which represents a four-fold gain for these two areas.

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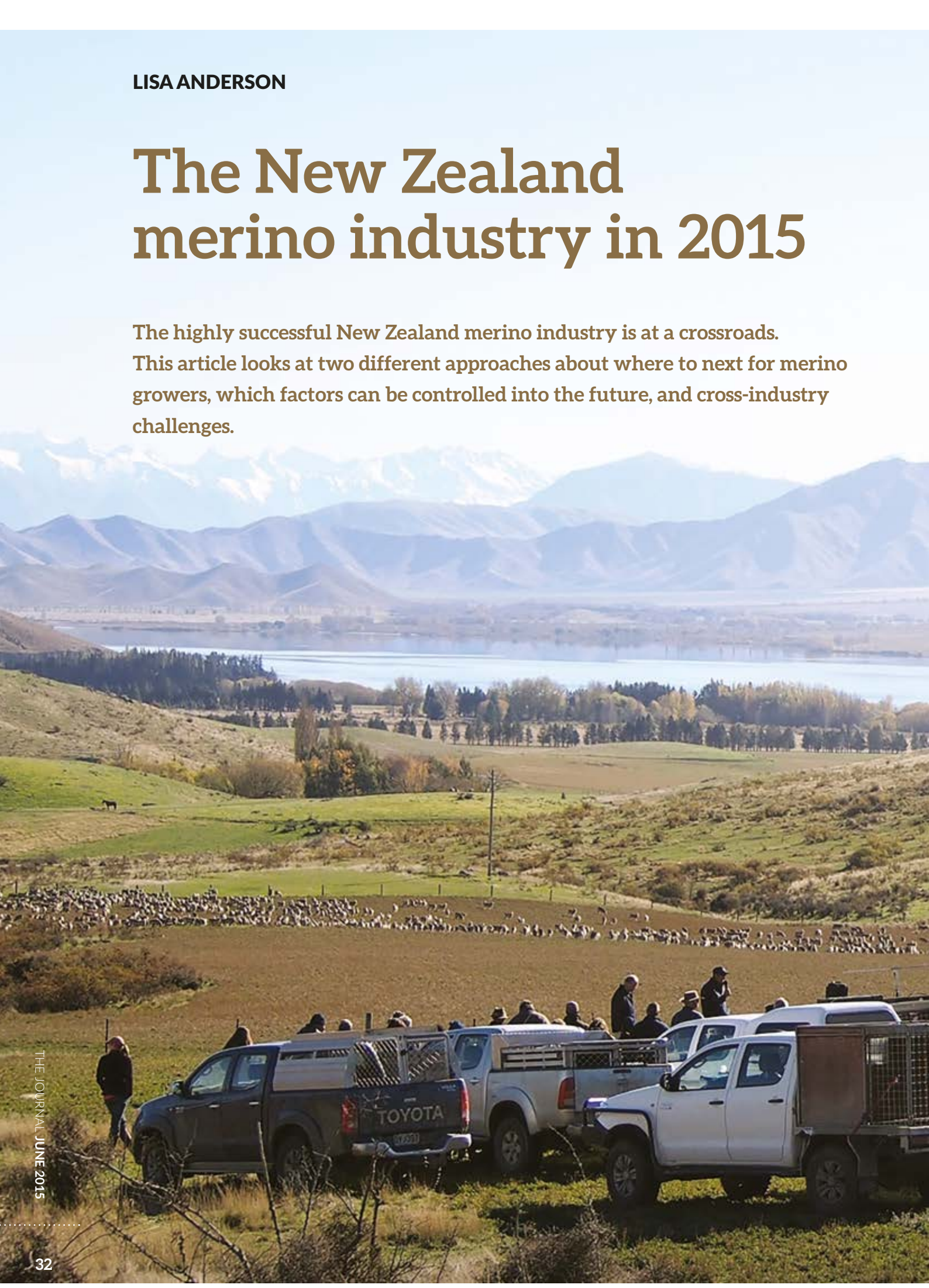
LISA ANDERSON

The New Zealand merino industry in 2015

The highly successful New Zealand merino industry is at a crossroads. This article looks at two different approaches about where to next for merino growers, which factors can be controlled into the future, and cross-industry challenges.



Changed focus

Historically introduced to New Zealand for its fine wool in the early 1880s, the merino breed has established itself as the sheep of the high country. With this has come a form of romanticism, the ram especially with its impressive long spiralled horns. The merino is an excellent forager and very adaptable. It has been bred mainly for its wool, and due to this its carcass size is generally smaller compared to sheep bred for meat.

Merino wool has up until recently been valued high enough to not focus on the animal's carcass and reproductive performance. For example, over the past five years the average value of our own 17.6 to 18.0 micron wool has varied from $7.40 to $11.94 per kilogram clean. This very large variation in income has resulted in us stopping and looking at our system. Many growers like ourselves have come to the realisation that income now has to be sought from elsewhere if we are to survive. An increase in lambing percentage has been the obvious choice, but due to many decades of breed selection on wool this trait cannot be realised overnight. The main reason for this is that wool production and reproductive performance are antagonistic traits.

Field day held at Bog Roy Station discussing the merits of lucerne in a dryland farming system.

Where to from here?

Merino growers appear to be split into two main groups – the believers and the non-believers. Believers in the breed are tweaking their systems to get the most out of their flocks. One of the more notable changes in the industry is the introduction of estimated breeding values (EBVs) in rams by many stud breeders. This uptake is quite recent, as initially there were only about three studs that used them. The ability to now select for traits such as eye muscle area, post-weaning weight or number of lambs weaned is allowing growers to take their flocks where most would have thought not possible as recently as five years ago.

There is concern that the current exodus of growers from the merino industry runs the risk of the loss of critical mass for New Zealand merino as a whole.

This second group of non-believers is mainly comprised of growers who are exiting the breed, either by bringing in other ram breeds to produce half-bred lambs or by ridding themselves of their merino flock entirely and going either cross-bred or half-bred. Reasons behind this group abandoning the breed are varied, but most have not been realising the potential of the merino for a variety of reasons including:

- The type of merino, for example, a 14 micron, 50 kilogram ewe clipping 4.0 kilograms and having a 85 per cent lambing percentage versus an 18 micron, 65 kilogram ewe clipping 5.5 kilograms of wool and having a 120 per cent lambing percentage
- Constant low lambing percentages through low feed inputs and historic trait selections. However, the merino ewe has done extremely well given their historical treatment – their high fecundity has taken them through so far. There is currently a lot of movement within the industry to try to educate merino farmers about feeding correctly at the right times, teaching them how to condition score and so on
- Ongoing problems with foot rot in mainly higher rainfall areas.

So who is right – the believers or non-believers? Only time will tell. Many would question why merino farmers have not been doing what the rest of the sheep industry has been for decades. My belief is that historic wool prices have allowed us to get complacent. Some would even go so far as to say that the worst thing that ever happened to the merino industry was the merino wool boom in the 1980s. This placed all the focus on wool production and built in an element of arrogance and complacency within the industry.

This begs the question – if growers were receiving $200 plus per ewe for wool without too much in the way of inputs, why worry about lambing percentages? Merino wether flocks are great examples that this system has been successful. They have made good money out of marginal country without necessarily having a lot of input in many cases, only coming into human contact once or twice a year for shearing and crutching musters. Conversely, sheep growers in the cross-bred industry have been getting good income from their lambs at the expense of their wool quality and quantity. Neither is right or wrong – it is what has worked in each respective scenario.

Factors to control

There is concern that the current exodus of growers from the merino industry runs the risk of the loss of critical mass for New Zealand merino as a whole. However, on the upside many are staying on. Here we are seeing growers concentrating on factors they can control such as:

- Feeding
- Maintaining the condition of ewes by condition scoring
- Monitoring of flocks for worm burdens, mineral deficiencies and weight
- Focusing on breed traits
- Improving ewe body weights, especially when going to the ram
- Increasing lamb birth weights and weaning weights
- More subdivision of properties for improved grazing management
- Small lambing mobs for better lamb survival
- Better pasture species for improved nutrition, mainly aiming for higher legume content in all pastures.

It is through all of these factors that remarkable changes are occurring within the merino industry, but there is certainly no silver bullet. However, getting all or many of these things right throughout the year has delivered great improvements to our own system (see **Table 1**).

Table 1: Bog Roy Station flock reproductive performance 2009-2014

	2010	2011	2012	2013	2014
Mixed age ewes					
Scanning %	150	165	165	165	164
Tailing%		115	123	130	124
Lamb losses%		30	25	21	25
2- tooths					
Scanning %	111	114	128	129	140
Tailing%		82	98	100	100
Lamb losses %		28	23	22	28
Average Flock Lambing %	104	107	117	123	120

There is also increased help for the merino industry. The New Zealand Merino Company has been active in securing government assistance in the form of Primary Growth Partnership funding and they have focused investment into areas such as:

- EBVs
- The Central Progeny Testing programme
- On-farm forage trials with Lincoln University.

The company has also been proactive in the instigation of other merino products, such as Silere Alpine Origin merino meat and more recently merino leather. They are also helping farmers at an on-farm level and running Bred Well Fed Well workshops and the Lifetime Ewe Management Programme. Both are designed to help growers get more out of the genetic potential in their flocks through targeted nutrition and improving the performance of each ewe as well as her progeny. Both programmes teach condition scoring to aid with decision-making around feed allocation and how to incorporate this information into the farming system.

Stud growers are also making large improvements. While there has been a significant move to the use of EBVs, there has also been a large shift in the improvement of and searching for better genetics offshore. At a local level, merino scholarships are available and are encouraged to foster the next generation of growers. For example, the Otago Merino Association has the annual Monaro Scholarship where the successful applicant spends time in the Monaro district in Australia learning about their systems. There is also the South African Exchange, a Gordon McMaster Trust and Otago Merino Association joint venture, where successful applicants go to South Africa for a month to learn about merino systems there.

Victim of success

Merino wool was historically a commodity, and in the 1990s growers decided to separate themselves from other breeds of wool by the establishment of the New Zealand Merino Company. This move has been very successful, with the product branded into a niche market and whole clip contracts lasting up to three years offered to growers. However, history dictated that this success would not last forever. Common sense also indicated that when something is profitable and successful there is always someone else who will come along to get a slice of the pie. We have ultimately become a victim of our own success.

Other industries have experienced challenges. The deer industry, alpacas, goats and dairy have all been through some form of pain during the years following stages of success.

The merino brand has been overwhelmingly successful to the extent that almost all outdoor retailers have garments made out of this wool. Consumers do not question the attributes and benefits of merino wool as they have proven their regard for it with their wallets. However, this has now resulted in it becoming once again a commodity. Quality brands such as Icebreaker, who use ethically produced New Zealand merino, are now competing with generic products from companies such as Macpac and Kathmandu who source merino from countries including China and Australia. These companies work on moving higher volumes of product at lower margins. Most consumers are again voting with their wallets, deciding to pay less for what is perceived to be an equivalent product.

Cross-industry challenges

This situation is not unique as other industries have experienced challenges. The deer industry, alpacas, goats and dairy have all been through some form of pain during the years following stages of success. Where the merino industry is unique is the ability for growers to be involved with a product from its inception to the finished product. We can wear our produce and be proud to do so. Growers have the chance to be involved in a product that is world class – merino wool is still a niche product because ethically-minded consumers choose to pay more. Our story fits the product – our imagery and history of the high country, our farmers, the majestic horned rams. All of it fits together like a hand in a glove – a marketer's dream.

No room for complacency

However, we cannot become or stay complacent. The world has shifted and wool is not the main earner it used to be. Merinos, a true dual-purpose sheep breed, need to be producing more lambs at a higher weaning weight and with a fine micron fleece. Do this and the merino will be hard to beat. However, to do this involves growers looking in the mirror – weaning small merino lambs in the middle of summer is not going to keep us on the land. Growers need to look at what the market wants – weaned lambs at good weights that will continue to grow out quickly before the winter to be able to compete with their cross-bred cousins, but with the added bonus of a valuable fleece.

The believers are rising to the challenge, but at the same time the non-believers are exiting the industry. The New Zealand merino industry is definitely at a crossroads and only time will tell who got it right.

LISA ANDERSON and her husband Dave farm merinos on Bog Roy Station, which is situated between Omarama and Otematata in the North Otago region.

JILL GREENHALGH

Vanuatu – growing its agricultural sector

Several years ago my daughter visited Tonga and commented that one just needed to put a stick in the ground and it would grow. I thought this was a slight exaggeration, but since coming to Vanuatu I have discovered this is how the self-sufficient, or subsistence, farmers operate. As around 80 per cent of the population are rural dwellers, reliant on agriculture for their food and well-being, self-sufficient farming is an important feature of the local economy. This article describes the physical Vanuatu, which has an important bearing on the improvement of agriculture, and touches on its history and current economy, prior to a discussion of its agriculture and the problems faced.

Background

Vanuatu, known as the New Hebrides before Independence in 1980, is a Y-shaped chain of 13 principal and 70 minor islands stretching 850 kilometres from 13°S to 21°S latitude. Around 40 per cent of its 1.2 million hectares is good agricultural land. Of this, 90 per cent is customary land with the remainder freehold or public land. Vanuatu sits on the Pacific rim of fire, making it earthquake-prone, but the active volcanoes provide some islands with rich volcanic soil. Most of the main islands are the summits of mountain ranges rising from the deep ocean floor, so agriculture is mostly restricted to the coastal plains. One-third of the land is above 300 metres.

In early ni-Vanuatu society people lived in small clans separated by ravines, jungle and the sea, so each clan had its own language and the people were not able to communicate easily with their nearest neighbours. Today the mother tongue of many children is still their local language. The common language is Bislama, a Creole language developed on the trading ships in the 19th century. Due to the French-English Condominium, which ruled the country from 1906 until 1980, education is still delivered in either French or English so people here speak at least three or four languages.

The arrival of the missionaries in the mid-1880s had a profound effect on the local cultures and customs of ni-Vanuatu and it retains a mix of Christianity and kastom (custom). The country gained its independence from Britain and France in 1980. The Prime Minister is the head of government of the Republic of Vanuatu, but since September 2008 there have been 10 changes of Prime Minister. The instability of this political system does not help the economy grow.

The population is estimated to be around 235,000 people, but it has one of the highest growth rates (2.3 per cent) in the world and at this rate it will double by 2050. It is a young population with a median age of 20.6 years, compared to 37.3 years in New Zealand. This growth is putting pressure on some of the agricultural land. There is also considerable urban drift to Port Vila, the capital city on the island of Efate, and to Luganville on Espiritu Santo.

The climate varies from wet tropical in the north to sub-tropical in the south with areas of drier rain-shadow. The weather patterns are divided into the dry season from May to October, with fresh south-easterly trade winds and fine sunny days, and the wet season from December to March when temperatures are warmer and heavy rain

Agriculture is a very important sector, making up around 73 per cent of total exports in 2007 and accounting for 17 per cent of GDP.

Vanilla farmer and extension officer

is common. This is also a cyclone season when there is a high probability that Vanuatu will be struck by hurricane force winds. Risk mitigation and reduction is an important concern for many of this country's donor organisations. The wet season brings challenges from pests and diseases so many vegetable crops are only grown in the dry season. The average annual rainfall varies from 2,286 millimetres in the south to 3,937 in the north.

Tourism is the fastest growing sector, generating around 20 per cent of GDP and employing about 11,000 people.

Economy and infrastructure

Vanuatu has recently shown a respectable level of GDP growth, averaging 5.7 per cent per annum between 2003 and 2009, partly due to opening up telecommunications and aviation as well as the doubling of tourist arrivals between 2001 and 2011. As in most developing countries, agriculture is a very important sector, making up around 73 per cent of total exports in 2007 and accounting for 17 per cent of GDP. Copra, kava, coffee and beef have been the leading export products followed by cocoa, timber and fish, but this sector is not growing. The value of imported goods far surpasses the value of exported goods, with food and drinks accounting for about a fifth of imports. Materials for construction, electronic equipment and transport equipment are also significant imports.

Tourism is the fastest growing sector, generating around 20 per cent of GDP and employing about 11,000 people. Vanuatu has two separate tourist industries – those who arrive by plane and stay and travel, and the much bigger sector, those who come by cruise ship and disembark for the day. They eat little, spend a token amount on local products, but contribute to the tourist activities that have been developed on Efate. Some of the cruise ships do have other stopping places such as Champagne Beach on Espiritu Santo, contributing significantly to the economies of the local villages. Tourism offers farmers another market if the resorts buy and feature local food. However, there still appears to be plenty of opportunity for import substitution if enterprising farmers can provide a reliable supply of high quality fruits and vegetables.

A huge problem for the agricultural sector and for the provision of basic services is the island geography, scattered population and the lack of infrastructure. Only three of the islands – Efate, Espiritu Santo and Tanna – have much in the way of roading. Efate has a ring road around the island built over four years ago, which has encouraged the development of tourism and also given the more remote farmers better access to the Port Vila fresh food market.

Espiritu Santo has a good quality road on its east coast, but much of its west coast is only accessible by boat. Tanna, with its easily accessed volcano, Mount Yasur, is a tourist destination. However, transport and freight costs to and within the islands are expensive. There are airfields on the main islands but flights are costly. The main islands are also serviced by ferries, but these are also relatively expensive and not always reliable. Only Efate and Espiritu Santo have retail outlets for agricultural supplies.

Agriculture

Agriculture in Vanuatu has three distinct sectors – the self-sufficient sector, a semi-commercial sector and the declining commercial sector.

Self-sufficient sector

The self-sufficient sector makes up 75 per cent of the agricultural sector and mainly produces food crops, with some small animal production. On average, rural households have five pigs and 16 chickens. The pigs may be used for ceremonial purposes, income generation or for home consumption, while the chickens tend to be used for meat rather than egg production. They may also have a few cattle, which are often tethered.

The important crops are the root and tuber crops – yam, taro, manioc (cassava) and kumala (sweet potato). The main vegetable eaten is the shrub known as island or slippery cabbage (*Abelmoscuhus manihot*), but it is supplemented by a wide range of fruits and nuts grown in the villages and gardens. These include citrus fruits and bananas, papaya, coconuts, pineapples, passionfruit, water melons and mangoes along with many fruits not familiar to New Zealanders. Avocados are also commonly grown.

Land is cleared each year and first planted in yams, which is a ceremonial plant, and the other crops follow. For crops such as manioc, island cabbage, bananas and pineapples it is almost a case of putting a stick or slip in the ground and coming back to harvest the crop later. After a few years in production, the ground will be left

Port Vila market

fallow for a period of time. It will regenerate into semi-forest and the heights of key indicator trees tell the farmer when it can be cleared again for replanting. Pressure on land reduces the fallow period in some areas, resulting in greater weed infestations and lower soil fertility. Rural livelihoods are said to be characterised by 'subsistence affluence' along with 'poverty of opportunity'. With only a low labour input, agriculture is able to sustain most families and absolute poverty is absent.

Semi-commercial sector

In recent times a semi-commercial sector has grown to account for about 15 per cent of the agricultural sector. These farmers produce the traditional root and tuber crops, plus the garden fruits along with newer vegetables (including tomatoes, capsicums, green beans, eggplants, Chinese greens, red and green cabbages, spring onions, carrots and pumpkins) and some herbs and spices (ginger and turmeric). Much of this has developed to support the urban centres of Port Vila and Luganville. Tanna, with its cooler climate, exports carrots, cabbages and some onions to Port Vila. There is some evidence that vegetables are now making a bigger contribution to local diets as well, with cash sales within and between villages. Other important cash crops are kava, coconuts and cocoa (mainly in the north), coffee in Tanna, and spices, particularly vanilla and peppercorns.

Small animal enterprises can contribute cash and improve diets. The Farm Support Association I work for has had a chicken project for 14 years. It buys day-old commercial chicks sourced from New Zealand and they are raised for 10 to 14 days and then go out by plane or ship to the islands. Unlike the local chickens, which fend for themselves, these are raised in hen houses. Approximately half are layers and the sale of eggs contributes to the household's cash income. The roosters are raised and sold for meat. The Association provides chick-raising and layer feeds, but a diet using locally sourced copra meal and meat meal from the abattoir ensures the poultry are economic and grow quickly and lay well.

Local pigs are usually either kept as a herd in one outdoor pen or allowed to range freely; one of the hazards of driving around Efate is pigs wandering on the road. The Association has been working with farmers to encourage them to house their pigs, which safeguards gardens and allows them to be better fed. The local pigs have often been inbred and therefore tend to be small but hardy. Ensuring that higher quality boars are used results in a better return to farmers.

Commercial sector

The remaining 10 per cent of commercial farms grew out of the plantation sector that developed after the arrival of the European settlers who planted large tracts of land with coconuts, cocoa and coffee. Larger plantations were developed on the extensive flat lands on Santo and Efate, while smaller plantations were found on Malekula, Pentecost and Epi. Following independence these lands were returned to their customary owners, some of whom leased them back to the plantation owners.

Cattle were initially introduced as early as 1845 to provide meat and milk for the European community. The farmers then increased cattle numbers in order to keep the plantations clean and finally raised cattle for beef. Today it is most common to see cattle grazing under coconut palms. A cattle census was carried out in 2007 recording nearly 175,000 head of cattle, of which almost a third were kept in lands without paddocks. Some of the beef is exported, but local good quality and reasonably priced beef and veal can be found in the supermarkets.

As a very small country with a low level of production and high transport costs to everywhere, access to international markets is extremely difficult except for small volume niche products such as vanilla and virgin olive oil.

Problems in improving agriculture

It is perhaps not surprising that many of the problems that agriculture faces in Vanuatu are similar to those found in New Zealand:

- Lack of skilled labour
- Poor public perceptions of agriculture as a career
- Volatility of world prices
- Reliance on commodities
- Rising input costs
- Difficulty of raising productivity through the adoption of innovation.

Lack of direction

However, Vanuatu faces additional hurdles to improving agriculture. Up until recently the government has not provided any direction for this sector. In 2014, an agricultural policy was developed and has been approved but it is still in draft form. Even once approved, it is unlikely that it will have much effect as the government has little money available and struggles to finance basic services such as health and education.

The Department of Agriculture and Rural Development sits within the Ministry of Agriculture, Livestock/ Quarantine, Forestry and Fisheries and offers an extension service to farmers. A review of these extension services was undertaken in late 2006 for NZAid. This found that the department had aging extension staff (mostly based at the provincial headquarters), operational funds were limited, and that they lacked transport, had few projects, showed a general lack of direction and motivation, and had weak management. I have not heard of any evidence to suggest there has been much improvement since then.

The Farm Support Association appears to be the only local non-government organisation offering extension services outside the government. The Association emerged in 1983 with the aim of helping the customary landowners who were given back the plantations to relearn agricultural skills. Today it is a very small non-government organisation. It works partly in development with donor funding and partly in user-pays areas such as training vanilla farmers and implementing the internal control systems required for organic certification, or in carrying out agricultural work for other agencies.

Transport issues

As a very small country with a low level of production and high transport costs to everywhere, access to international markets is extremely difficult except for small volume niche products such as vanilla and virgin olive oil. Unlike Fiji, which acts as a transport hub in the Pacific, Vanuatu is simply a tourist destination with few flights, offering little scope for the export of products. Also unlike Samoa, with only two main islands linked by a regular ferry, Vanuatu's 13 main islands are a much greater challenge to service. There are no refrigeration facilities outside of the two main centres. Also, there are no competent authorities to promote agricultural products and cooperatives tend to have short lives in the Pacific.

Farmer isolation

An even bigger barrier to raising productivity is the sheer isolation of most farmers. They do not have the ability to work together due to this isolation and the lack of infrastructure, as well as being hampered by low literacy and numeracy. When the Association runs a workshop or field day, a field officer goes to the area in the week before the intended event and visits each farmer. Given the price of flights to the other islands, the high cost of internal travel and the time involved, working with farmers is extremely expensive. Mobile coverage has improved communication, but it is not everywhere, and with no provision of electricity outside of Port Vila and Luganville charging a mobile phone is not as simple as plugging it into a wall socket.

Land ownership

As in many developing countries where land ownership is customary rather than private, this can create problems and be a disincentive to adopting new practices. For example, the Association encouraged the use of alley cropping where sloping land was stabilised by planting nitrogen-fixing trees along the contours and the crops were planted along the resulting alleys. Uptake was poor, partly because planting permanent trees was seen as planting ownership on the land which was unacceptable in many villages. Disagreements over land ownership are not uncommon and because of this the land is not being well utilised.

Credit

Credit is difficult to obtain as the average financial institution in Vanuatu does not regard agriculture as a potential and profitable investment. VANWODS is a micro-credit organisation established in 1996 which has catered

to women with some success, but these are mostly urban women. Women tend to grow vegetables for sale, as well other household crops. Men mostly control the production of cash crops – and the use of the proceeds. Few women have assets to offer as security for loans.

Agricultural education

Agriculture is typified by falling numbers of farmers, increased urbanisation and educated youth who do not see this sector as offering a viable career. As in many countries, agriculture has a low status. The University of South Pacific's Samoan campus hosts the agricultural faculty so those wanting a tertiary qualification must go to Samoa, but the courses lack a vital practical component. The Vanuatu Agricultural College on Santo was built by the Chinese, but unfortunately it has little land attached and so is limited in its ability to provide practical experience.

Many young people do not complete an education above Years 6 to 8, i.e. 12 to 14 years of age, as school fees are relatively high for secondary education. There are Rural Training Centres (RTCs) throughout the country, which offer further vocational training to school leavers, often in the trades or in hospitality or tourism, and a few in agriculture. These are not funded by the government so rely on local community support to operate.

Disagreements over land ownership are not uncommon and because of this the land is not being well utilised.

The Farm Support Association supports two RTCs and they have adapted the Tutu model from Fiji, with the aim of taking young people and turning them into professional farmers who will farm as a business rather than as a livelihood. The courses encourage girls to enrol, but all students must have guaranteed access to land in their village area for the three years of the course.

Students are allocated small plots of land at the RTC and work these alternatively with their own land. The proceeds from some of the produce sold is banked, with the aim of the students graduating after three years with 100,000 vatu in savings. They are also expected to have established plantings of a cash crop to provide further income. This is mostly kava, which takes three years before it can be harvested. Students will also have accumulated tools and other assets, along with the knowledge to grow and market vegetable crops.

Agrochemicals and organics

Unlike many Pacific islands, Vanuatu farmers have so far not started using agrochemicals to any extent. Most beef farmers resort to herbicides to control weeds and most of the fruits and vegetables are grown free from sprays or fertilisers. Organics is a growing movement within the

Pacific, but it is difficult to promote an organic product in a country where most of the produce is grown organically. Third party organic certification is very expensive and the premium farmers are paid would barely cover the cost of certification. Donors often subsidise certification, but it would be disappointing if Vanuatu lost its honestly earned clean green image.

Summary

Agriculture will continue to be the foundation of the Vanuatu economy for the foreseeable future. The aim will be to move the self-sufficient farmers towards becoming semi-commercial farmers. The funding and motivation for this will need to come from donors and their funding. Climate change adaptation and disaster risk management are the important words for obtaining funding, but many donors know little about agriculture. The Farm Support Association will continue to work slowly and steadily with its farmers, but they are just one tree in the rainforest. Eventually farmers will need to learn how to farm beyond putting a stick in the ground and waiting for it to yield.

UPDATE – CYCLONE PAM

Since writing this article, Vanuatu was struck by Cyclone Pam in March 2015. This Category 5 tropical cyclone brought wind gusts of over 300 kilometres per hour. It has affected the lives of over 70 per cent of the population across 22 islands. All trees lost all their fruit – bananas, pawpaw, avocados, citrus and nuts. Most of the root and tuber crops were destroyed. Even if farmers have the time to replant immediately, the quickest crops such as kumala, maize and manioc will take at least three months to start to produce. Local building materials have also been destroyed. Rebuilding the lives and livelihoods of farmers will be a formidable task.

JILL GREENHALGH worked as a Social Science Researcher in agriculture at Lincoln University for five years before moving to Port Vila, Vanuatu in June 2014 as a VSA volunteer. She is currently a Research/Information Advisor for the Farm Support Association, a small agricultural non-government organisation involved in extension work, development and education.

David Baker receiving his MNZM in 2014 from the Governor General Jerry Mateparae

NZIPM PROFILE

David Baker

David Baker has worked for 46 years as a farm management consultant in the Wairarapa. At 72 he is still actively involved in farm supervision and a decreasing number of farming families as he moves into semi-retirement.

Sharemilking and herd testing

Originally from Auckland, David spent a large percentage of his school holidays with different relations who were dairy farmers in the Waikato. He was determined to have a farming career and became a dairy farm cadet on a sharemilker's farm at Te Awamutu, at the same time joining Young Farmers.

His starting wage was £3.17.6 per week, and his aim was to go sharemilking but cows at that time were £30 to £35 each, with a herd of around 80 seen as economic. David saw it would take a long time to save enough for a herd, but found that when he turned 18 he could become a herd tester. He was employed by the Auckland Livestock Improvement Association in this role for the next two-and-a-half years. This trebled his wage and they provided his transport, initially a horse and cart, which he used when based at the Waitoa dairy factory while training. In those days herd testing involved visiting and spending a night on 25 different farms each month.

Lincoln years

David's time working on a dairy farm and then herd testing focused his attention on getting a farming qualification so he decided on Lincoln. At that stage an entrant required a minimum of two years of practical farm work experience before acceptance for the diploma in agriculture. He was advised to get practical farm experience on a livestock and mixed cropping property before starting, so one year on a property at Carew in mid-Canterbury followed. He was fortunate in gaining a scholarship through Young Farmers

that was funded by Canterbury Frozen Meats and then a rural field cadetship. David commenced his diploma in agriculture and a diploma in farm management studies at Lincoln in 1964.

Rural field officer

The rural field cadet position had a three-year bond requirement to work for the public service and he was posted to the State Advances Corporation, the predecessor to the Rural Bank, in Timaru. In 1968 he was seconded back onto the staff at Lincoln to assist with field work projects, lecturing, and marking for both diploma in valuation and farm management students. He then returned to the State Advances Corporation in New Plymouth for a short stint before being head-hunted as an advisor for the Wairarapa Farm Improvement Club.

David still remembers the advice he received from Hec King who was head of the State Advances Corporation at the time. He advised that the employees they needed were people who could exercise sound judgement and deal fairly with clients. It was not a matter of whether they could write good reports or play good rugby and be good social ambassadors – their success would be measured by the success of their clients.

Baker & Associates

Commencing as a Wairarapa farm advisor in 1969, David went on to establish Baker & Associates (Wairarapa) Ltd in 1986 when his partner Chris Garland joined him. Since then the firm has grown and is operating New Zealand-wide with 17 people as partners or employees. He is still involved with farm families he first took over as clients in 1969 if needed. In several cases he deals with the third generation of clients he started with, and in one case a fourth generation.

David started a rudimentary form of benchmarking analysis in 1969 for his Farm Improvement Club clients. This has now evolved into the Financial Analysis Bureau (FAB) that Baker & Associates still operate. There is an annual publication of farm business results that show an individual client's key performance results in comparison with the average for properties of a similar class and also with what the top 10 per cent are achieving. This information is used to identify the specific areas of a farm business operation that might benefit from a review and change.

Associations and appointments

The move to Masterton coincided with the foundation of the New Zealand Farm Management Society, the predecessor of the renamed NZIPIM. David became a foundation member of the Society and chairman and councillor for its newly formed Wairarapa-Wellington branch. He was also a Council member of the Society and served as national president from 1979 to 1981, and was made a Life Member of the New Zealand Institute of Primary Industry Management (NZIPIM) in 2001. Over recent years he has been a member of the complaints committee for disciplinary matters.

His appointment to the New Zealand Fertiliser Manufacturers Research Association by the Minister of Science and Technology from 1982 to 1986 was the first of seven government appointments. He also served on the Registration Board for Primary Industry Consultants from 1983 to 1997. The most significant appointment was as a founding trustee for the New Zealand Rural Trust, set up in 1988 to help farmers caught up with the removal of subsidies and support to the agricultural sector. It was succeeded by the formation of regional rural support trusts that continue to operate today. Another appointment was in 1986 as leader of a special assessment group set up after the South Canterbury floods to provide targeted assistance to farmers who had suffered more than $10,000 of non-insurable damage.

When David was at Lincoln he was told that the maximum life of a Farm Improvement Club advisor was five years, because after this the farmer would have picked your brains and would need to get someone new to keep them ahead. He has spent many years servicing farming clients, but it has been their needs that have changed every five years, not the advisor.

David has been a JP since 1994 and completed a judicial qualification in 1999 which enables him to undertake court duties, including issuing search warrants. His commercial directorships have included being director of Ravensdown Fertiliser for 21 years, of Fieldair Holdings and Animal Enterprises Ltd for three years each, and chairman and director of Wairarapa's largest orchard for seven years. He has also been a member of the Wairarapa Land Valuation Tribunal, and briefly the Wellington No. 2 Tribunal.

David was awarded an MNZM for services to agribusiness and the community in the Queen's Birthday 2014 Honours list.

Dealing with clients

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ahead. He has spent many years servicing farming clients, but it has been their needs that have changed every five years, not the advisor.

He has tried to stay relevant by anticipating and providing the services his clients require. David keeps asking himself, where is agriculture heading and what are the future needs of his farming clients likely to be? Also, how can he better challenge them and help them achieve their goals and objectives? For him, the best way to deal with farming clients is to act as a mentor, coach and sounding board. Also, to encourage team work and be prepared to listen and make use of the skills of those around you.

Farm succession is fraught with difficulties and requires careful planning and implementation. Consultation needs to involve the whole family as well as other professional advisors such as an accountant, solicitor, trustee and banker.

He has the strong view that culture, attitude and values need to be set from the top, i.e. if you are leading a team you need to lead by example. A consultant needs to recognise that their professional and personal reputation is paramount, but this takes time to build and can be lost very quickly. At Baker & Associates the need to keep up to date by attending conferences and continuing education opportunities is recognised and as a firm they attempt to act professionally and independently at all times. Their focus has been on how they can better anticipate and service client needs as the business environment changes in both the short and long term. If conflict arises, effective communication and mediation are seen as the best means of resolution. Any job worked on must be correctly documented, then formal litigation should become a last resort.

For David, the most effective means of supervising a property is to ensure the selection of the person with the required skills and experience and then empower them to take responsibility, while being accountable for working within any policies or budget guidelines provided. There is no point in employing a manager and then having to closely direct them; monthly monitoring should be the aim rather than weekly checking and directing.

Farm succession is fraught with difficulties and requires careful planning and implementation. Consultation needs to involve the whole family as well as other professional advisors such as an accountant, solicitor, trustee and banker. A consultant is in an ideal position to facilitate this process, but must be prepared to stand back from involvement beyond their training in areas such as legal documentation and tax planning. David has never invested personally or got financially involved with a client's business as he feels this would risk loss of independence and be a potential conflict of interest. He also considers very carefully before accepting an invitation to act as trustee or director for a client.

In his view a farming client needs to focus on what they can do well, and they can then be assisted with defining their realistic achievable goals given the resources they have. On reflection, David believes his role is more accurately described as a farmer consultant. He could have had six different owners/managers on the same property but his advice to them might be very different after taking into account their objectives, skills and the resources they can access.

He has firmly adopted the approach taught at Lincoln which focused him on the need to take a whole-farm perspective, with people being the main factor. This means taking full account of all factors, starting with the farm physical components of location, contour, soils and climate, in combination with the finance available, and the objectives, desires and skills of the farm owner/operator.

When called upon by a client to provide advice and any recommendations he has always attempted to act as a coach and sounding board, ensuring that the full ramifications are considered rather than dealing with narrow problem-solving. He explains why a certain action is proposed and the principles behind it, recognising that it is the people that run their farms who are the most significant component. In his view, management implementation is more important than strategic planning and policy formulation.

Semi-retirement

When David reached 65 he sold his shares in the company he founded to allow younger partners to advance. The firm name of Baker & Associates (Wairarapa) Ltd was retained and he agreed to continue as a consultant back to the firm. He was provided with an office so he could continue to service his clients and attend to referred jobs that required his expertise. He acts as a mentor and still assists with the annual benchmarking publication.

David is now working three to four days each week. This includes supervising a property for the Presbyterian Church in Hawke's Bay, continuing to supervise farm leases, as well as acting as trustee, executor or consultant to the farming families he has had long-standing involvement with. He tries to play golf once a week, is an active member of the Masterton South Rotary Club, and has been part of a philosophy group and plays weekly bridge. He now has more time for international travel with his partner, Yvonne, and for spending time with his grandchildren, four of whom live in Kuala Lumpur. J

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